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DARLINGTON NGS FEEDER VIBRATION

Report No 88-274-K

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ABSTRACT

Vibration monitoring was performed on selected feeders as part of the commissioning program at Darlington NGS 'A', Unit 2. The monitoring was performed to validate stress analysis predictions. The monitoring procedure, evaluation criteria and results of the monitoring program are documented in the report.

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EXECUTIVE SUMMARY

DARLINGTON NGS FEEDER VIBRATION

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Vibration monitoring was performed on selected feeders and instrument lines off the main headers at Darlington NGS 'A', Unit 2. The monitoring program was performed during commissioning with the reactor unfuelled under cold and hot conditioning of the Primary Heat Transport (PHT) system.

The vibration monitoring program was performed to validate stress analysis. Atomic Energy of Canada, Ltd (AECL), who had responsibility for the design and stress analysis of the feeders, specified the measurement locations and the acceptance criteria. The vibration monitoring program and data analysis were performed by the Plant Equipment Dynamics Section of Mechanical Research.

The results of the feeder vibration monitoring program revealed that the deflections of the instrument lines and feeders measured under two and four pump, unfuelled conditions were within the allowable ranges established by AECL.

TABLE OF CONTENTS

		Page
1.0	INTRODUCTION	1
2.0	ALLOWABLE VIBRATION CRITERIA	1
3.0	MONITORING PROCEDURE AND INSTRUMENTATION	1
	3.1 Procedure	1
	3.2 Instrumentation	3
4.0	RESULTS AND DISCUSSION	4
5.0	CONCLUSIONS	5
	REFERENCES	6
	TABLES	
	FIGURES	
	DISTRIBUTION	last page

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To

Mr. G. Childerhose
Production Manager
Darlington NGS

DARLINGTON NGS FEEDER VIBRATION

1.0 INTRODUCTION

A vibration monitoring program was carried out on the feeders and instrument lines off the headers at Darlington NGS, Unit 2. The vibration monitoring was performed during commissioning in order to validate stress analysis predictions.

Atomic Energy of Canada Ltd - Engineering Company, who had responsibility for the design and stress analysis of the feeders, specified the measurement locations and acceptance criteria/1,2,3/. The vibration measurement program and analysis of the data were performed by the Plant Equipment Dynamics Section of Mechanical Research in Ontario Hydro.

The tests were performed with the reactor unfuelled during cold and hot conditioning tests of the Primary Heat Transport (PHT) system.

The vibration monitoring work will be documented in the report and the results will be discussed in terms of the allowable vibration criteria.

2.0 ALLOWABLE VIBRATION CRITERIA

The vibration criteria for the feeders and instrument lines were determined by Atomic Energy of Canada-E.C./1/.

The maximum allowable deflection for feeders was established at 6.0 mm peak-to-peak/1,2,3/.

The maximum allowable displacement for the instrument tubing was 16 mm peak-to-peak. No contact with adjacent components was permitted. The specification for the instrument tubing allowed that a visual inspection of the tubing vibration would be adequate to verify the tubing design/1/.

3.0 MONITORING PROCEDURE AND INSTRUMENTATION

3.1 Procedure

The layout of the feeders is shown in Figure 1.

The technical specification for this work stipulated that a vibration screening survey be performed on 40 selected feeders during cold operation of the PHT system/1/. The screening survey was to be performed with portable vibration transducers magnetically attached to the feeders. The cold survey results were then to be used to select the six "worst case" feeders for vibration monitoring during hot conditioning. During hot conditioning the transducers were to be clamped on the six feeders and the cabling routed through penetration to the recording equipment.

During cold commissioning problems with PHT pump operation resulted in the curtailment of the cold run survey of the feeders and instrument lines. To ensure installation of the transducers and cabling in the vault, AECL was asked to select, on the basis of their stress analysis, six feeders for permanent monitoring during hot conditioning/4/.

The six feeders selected for permanent monitoring were:

- X8E and Y12E on the horizontal incline in the lower feeder cabinet, south side;
- C9E and C12E on the vertical rise of the feeders just at the lower edge of the feeder cabinet at the top of calandria;
- Y8E and Y9E on the long horizontal run off the headers in the upper feeder cabinet.

The locations for the permanent feeder monitoring are shown in Figures 1 and 2.

In the curtailed cold PHT system operation a brief survey was performed in the lower east feeder cabinet on the long inclined section of the feeders on the south side of the reactor. The following feeders were surveyed:

Feeder	Location on incline above elbow (see Figure 1)
Y9E	203 CM
Y8E	147 CM
V4E	99 CM
V5E	91 CM
W12E	117 CM
X8E	112 CM
Y12E	147 CM
X6E	183 CM
W8E	145 CM
X9E	152 CM

In addition to the lower feeder cabinet survey, transducers were also magnetically mounted on two additional feeders in the upper feeder cabinet: E12E and C12E. The transducers were mounted on the long horizontal spans of the feeders under the headers and the catwalk. These two feeders were monitored to provide additional data in the cold survey.

Monitoring of the feeder vibration was performed with the PHT system cold, heating up to hot conditioning and during hot conditioning. During the course of the hot and cold testing of the PHT system a resonance in the BALANCE line between outlet headers 5 and 7 was discovered, with associated high vibration levels. Feeder and instrument line vibration was also monitored during the investigation of the cross-over line resonance to determine the effect of the resonant vibration levels on the feeders.

The conditions under which feeder vibration was monitored are summarized below:

PHT SYSTEM CONDITION	FEEDERS MONITORED
T<50°C, 2 PHT pumps in operation, 67.7 mm orifice in balance line	6 permanent locations, lower feeder cabinet survey, E12E and C12E (magnetic mounts in upper feeder cabinet).
50°C<T<260°C, 2 and 4 pumps in operation, 67.7 mm orifice	X8E and Y12E (permanent locations in lower feeder cabinet), monitored continuously during heat up.
T = 184°C, 4 pumps, 67.7 mm orifice	6 permanent locations
T = 260°C, 4 pumps, 67.7 mm orifice	6 permanent locations
T = 260°C, P1 and P3 on, P4 turbining; 90 mm orifice in balance line.	C12E and instrument line
T = 250°C, P2 and P4 on, P3 turbining; 90 mm orifice in balance line	C12E and instrument line
T = 235°C, P2 and P4 on, P3 turbining; 90 mm orifice in balance line.	C12E and instrument line

3.2 Instrumentation

Vibration measurements were performed using piezoelectric accelerometers.

Feeder vibration was monitored using B&K 4321 triaxial accelerometer units which permit simultaneous measurement in three orthogonal directions. For the cold survey the triaxial accelerometer unit was attached to the feeders using a magnet. For the hot survey the accelerometers were mounted on ceramic blocks for thermal insulation. The ceramic blocks were then rigidly fixed to the feeders with hose clamps.

In all the feeder measurements the accelerometers were aligned such that the Y-direction represented the local axial direction on the feeder.

The instrumentation line vibration measurement was taken using a small B&K model 4275 accelerometer that was fixed to the line in the radial direction using a split clamp.

For the hot conditioning test the high temperature cables from the accelerometers were routed through a penetration in the feeder cabinet into the vault and then through a vault penetration in the south wall to the data recording equipment.

All vibration data were recorded in velocity. With the exception of the continuous monitoring performed during heat up to hot conditioning, all data were stored on magnetic tape. The tape recorded data were integrated in the time domain to displacement. Frequency spectra of the vibration data were produced via Fast Fourier Transform. The

data taken during continuous monitoring were recorded on strip-charts.

4.0 RESULTS AND DISCUSSION

The feeder and instrument line data are documented in Tables 1 through 10.

The highest deflections under cold, two pump operating conditions were experienced on the long inclined spans of the feeders in the lower feeder cabinet as shown in Tables 1 and 2. The maximum deflections were 2.5 mm peak which were below the established allowable of 3 mm peak. The maximum deflection was experienced by feeder Y9E in the lower feeder cabinet.

The peak velocity data from the lower feeder cabinet measurements, shown in Table 3, revealed fairly consistent levels which corroborated the visual evidence during the monitoring period. The high velocity levels, in excess of 40 mm/s, were isolated peaks, not representative of steady state levels.

The velocity spectra for the cold, two pump tests are contained in Figures 3 through 23. The dominant response frequencies, tabulated above each spectrum, are predominantly below 200 Hz. The dominant response at 150 Hz, evident mainly on the two permanent locations in the lower feeder cabinet, is due to excitation from the PHT pumps (5 blades @ 30 Hz). The dominant response at 397 Hz evident at some of the locations in the upper feeder cabinet is due to the resonance in the balance line between outlet headers 5 and 7. The peak data tabulated in Tables 1 through 3 represents the record during the occurrence of the tone on the balance line; therefore it may be said that the balance line problem did not adversely affect the feeder vibration.

The velocity data recorded during the PHT heat-up tests on feeders Y8E and Y12E in the lower feeder cabinet revealed that some high transient vibration was experienced by the feeders/5/. However, most of the high level vibration took place under 4 pump operation which is not representative of actual conditions with a fueled reactor and is in fact a severe condition for flow excitation. One data point, at 1930 hours on 88.04.30 was of concern as the vibration of the feeder was sustained at 200 mm/s for over one hour; however, a check with the control room records revealed that during this time period the LRV's lifted due to over-pressure in the main circuit, with subsequent pump shutdown and restart. The transients experienced under the aforementioned conditions would account for the high, sustained vibration response.

The displacement data from the feeders and instrument line during the warm-up, with T_{in} = 184°C, are documented in Table 5. The levels are all within the allowable of 3 mm peak. The velocity data for T_{in} = 184°C, from which the displacement data in Table 5 is obtained, are shown in Table 6.

The displacement and velocity data for four pump operation at a PHT temperature of 260°C, shown in Tables 7 and 8 respectively, revealed that the vibration response of the feeders was not adversely affected by the higher temperature operation compared to the four pump operation data during warm-up, Tables 5 and 6.

The response of the feeders during two-pump, high temperature operation is exemplified

by the data for feeder C12E and the instrument line, documented in Tables 9 and 10. The vibration levels are approximately one-half those levels experienced during four pump operation (Tables 5 and 6). The data for hot, two-pump operation are lower than those for cold, two-pump operation (Table 1), due to the diminished excitation from the 90 mm orifice in the balance line. The velocity spectra for the hot, two pump operation are contained in Figures 24 through 35. The spectra indicate that the frequency response of both the feeder and instrument line are not significantly affected by the increase in temperature. The only major shift in frequency in the spectra was that of the balance line resonance which changed due to the changes in orifice size and temperature.

The vibration monitoring program was performed on the assumption that two-pump, unfueled operation of the PHT system would be representative of four pump, fueled operation. The results indicate that even under four pump, unfueled conditions, which would result in very high flows in the feeders, the vibration levels were within the allowable range.

The only data that may be suspect in the tests are the instrument line displacements. The small accelerometer which had to be used to prevent mass loading of the instrument line had very low sensitivity. When low level, low frequency signals are integrated inaccuracies are often introduced. The visual inspection of the instrument lines in the feeder cabinets indicated that none of the instrument lines visible from the catwalks appeared to be in danger of fretting contact with the feeders. Some instrument lines which were in danger of contacting each other have been identified to Operations staff/6/.

5.0 CONCLUSIONS

The results of the feeder vibration monitoring program indicate that the deflections of the instrument lines and feeders measured under two and four pump, unfueled conditions were within the allowable ranges established by AECL-EC.

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HLA:is

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2. Memo to J. Lehman, Darlington Operations, "Darlington NGS 'A', TS-38-33160-006, Unit 2, Feeder Commissioning", from H.L. Anderson, Ontario Hydro Research, Feb 29, 1988, File 825.5.

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5. R.T. Hartlen, R. Elmaraghy, F. Slingerland, "Vibration Velocity as a General Sensitivity Criterion", CEA Thermal and Nuclear Power Section, Spring Meeting, March 16, 1982.

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TABLE 1

DARLINGTON FEEDER VIBRATION

2 PUMPS IN OPERATION, COLD CONDITIONS

displacement (mm peak)

FEEDER	Transv. displ.	Axial displ.	Radial displ.	Vector displ.
X8E	1.8	0.25	1.0	2.1
Y12E	0.6	0.54	2.3	2.4
C9E	0.8	0	0.16	0.81
C12E	0.38	0	0.16	0.41
E12E *	0.3	0.25	0.06	0.4
C12E *	0.31	0.63	0.22	0.76
Y8E	0.32	0.82	0.32	0.95
Y9E	0.7	0.1	0.57	0.9

* magnetically mounted probes on long horizontal span in upper feeder cabinet

TABLE 2

DARLINGTON NGS UNIT 2 FEEDER VIBRATION
lower feeder cabinet survey

Two pumps, Cold commissioning

Feeder ID	Location (cm up from elbow)	Displacement in mm peak X	Y	Z	Vector
Y9E	203	0.680	0.820	2.375	2.511
Y8E	147	0.800	2.125	0.820	2.405
V4E	99	1.975	0.949	1.150	2.193
V5E	91	1.750	0.500	1.425	2.307
W12E	117	0.850	0.510	1.325	1.516
X8E	112	1.100	0.886	0.850	0.982
Y12E	147	1.000	0.886	1.250	1.717
X6E	183	1.900	0.520	1.650	1.983
W8E	145	1.800	1.297	1.300	2.471
X9E	152	1.000	1.709	1.550	1.992

TABLE 3

DARLINGTON NGS UNIT 2 FEEDER VIBRATION
lower feeder cabinet survey

Two pumps, Cold commissioning

	PEAK VELOCITY (MM/S)		
FEEDER	X	Y	Z
Y9E	30	40	60
Y8E	40	30	125
V4E	70	24	45
V5E	84	25	60
W12E	60	25	68
X8E	40	19	40
Y12E	70	31	60
X6E	50	70	80
W8E	60	19	50
X9E	40	34	70

TABLE 4
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

HEAT UP TO HOT CONDITIONING

DATE	TIME	TEMP°C	CONDITION	FDR Y8E axial. vel. mm/s pk.	FDR Y12E radial vel. mm/s pk.
88/04/28	1430	180	4 pumps	40	90
"	2100			40	100
88/04/29	0100			40	100
"	0920	250		30	100
"	1900			50	100
88/04/30	1600			60	90
"	1930			0	200

DARLINGTON NGS UNIT 2 FEEDER VIBRATION

HEAT UP TO HOT CONDITIONING

DATE	TIME	TEMP°C	CONDITION	FDR X8E transv. vel. mm/s pk.	FDR Y12E radial vel. mm/s pk.
88/05/07	0915	60	2 pumps	80	80
88/05/09	0025			80	200
88/05/09	1314			70	80
88/05/10	1150			60	80-100
88/05/10	1650		4 pumps	80	80
88/05/11	1330	250	4 pumps	70	90
88/05/13	0900	250	4 pumps	70	140

TABLE 5
DARLINGTON FEEDER VIBRATION

FOUR Pumps, Warming up: Tin=184°C,Tout=178°C

Feeder ID	Displacement (mm peak) X	Y	Z	Vector
Y8 E	0.980	0.750	0.380	1.081
Y12E	1.350	0.690	2.500	2.892
Y9E	0.875	0.300	0.925	1.170
X8E	1.575	0.850	1.550	1.812
C9E	0.950	0.290	0.625	0.963
C12 E *	0.700	0.300	1.700	1.836
C12 E	0.400	0.170	0.550	0.573

INSTRUMENT TUBE : Radial Disp. with H/Pass filter at:

2Hz	lHz	OHz
0.310	0.500	0.830 mm peak

* record started with 3 pumps in operation and the fourth pump was restarted in the record.

TABLE 6

DARLINGTON NGS UNIT 2 FEEDER VIBRATION

HOT CONDITIONING
FOUR PUMPS, T_{in}=184°C, T_{out}=178°C

FEEDER	PEAK VELOCITY (MM/S) X	Y	Z
Y8E	40	56	88
Y12E	60	36	92
Y9E	40	20	58
X8E	52	20	55
C9E	70	30	60
C12E	28	18	30

TABLE 7

DARLINGTON FEEDER VIBRATION

FOUR Pumps, Hot : Tin=260°C

Feeder	Displacement (mm peak)			
ID	X	Y	Z	Vector
Y8E	1.350	0.675	0.950	1.468
Y12E	1.950	0.800	2.000	2.334
Y9E	1.450	0.425	1.000	1.398
X8E	1.300	0.425	1.700	1.818
C9E	0.800	0.260	1.650	1.716
C12 E	0.450	0.160	1.175	1.192

Instrument tube:
Radial Disp. with H/Pass filter at 2Hz: 0.094 mm

TABLE 8

DARLINGTON NGS UNIT 2 FEEDER VIBRATION

HOT CONDITIONING
FOUR PUMPS, T=260°C

	PEAK VELOCITY (MM/S)		
FEEDER	X	Y	Z
Y8E	40	40	60
Y12E	70	45	96
Y9E	60	20	60
X8E	44	20	60
C9E	60	36	56
C12E	30	20	30

TABLE 9

Darlington Feeder vibration - 90 mm orifice test

Two Pumps; hot: T_{in}= 250°C

P2 & P4 on, P3 turbining

Feeder C12E

	X	Y	Z	Vector
Displacement in mm peak:	0.180	0.259	0.149	0.319
Velocity in mm/s peak	24	16	40	45

Instrument Tube

Radial Displacement: 0.886 mm peak

Radial Velocity : 37 mm/s peak

TABLE 10

Darlington Feeder Vibration - 90 mm orifice test

Two Pumps
P2 & P4 on, P3 turbining

Feeder C12E

Temp PHT	Displacement in mm peak X	Y	Z	Vector
235°C	0.053	0.068	0.055	0.080
260°C	0.115	0.173	0.095	0.209

	Velocity in mm/s peak X	Y	Z	Vector
235°C	31	18	19	36
260°C	27	18	19	32

Instrument Tube

PHT Temp	Radial Displ. in mm peak
235°C	0.51
260°C	0.62

PHT Temp	Radial Vel. in mm/s peak
235°C	25
260°C	31

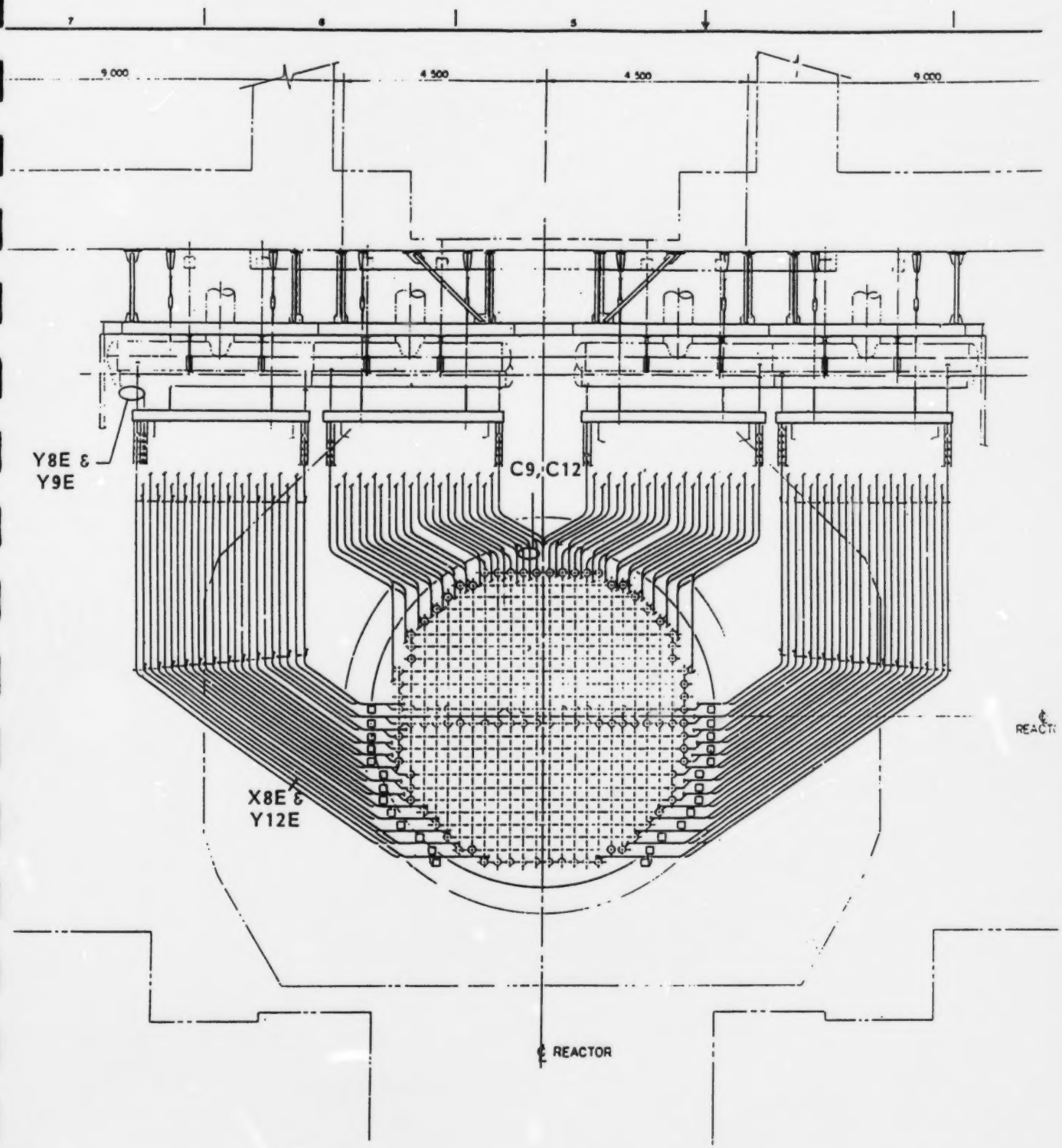

FIGURE 1

EAST FACE OF REACTOR
- PERMANENT MONITORING LOCATIONS SHOWN

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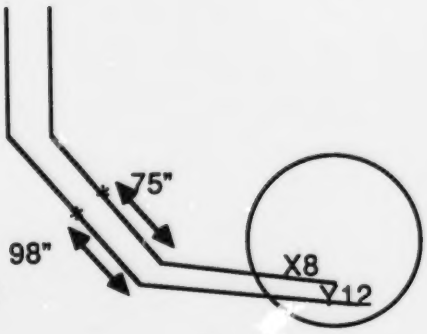
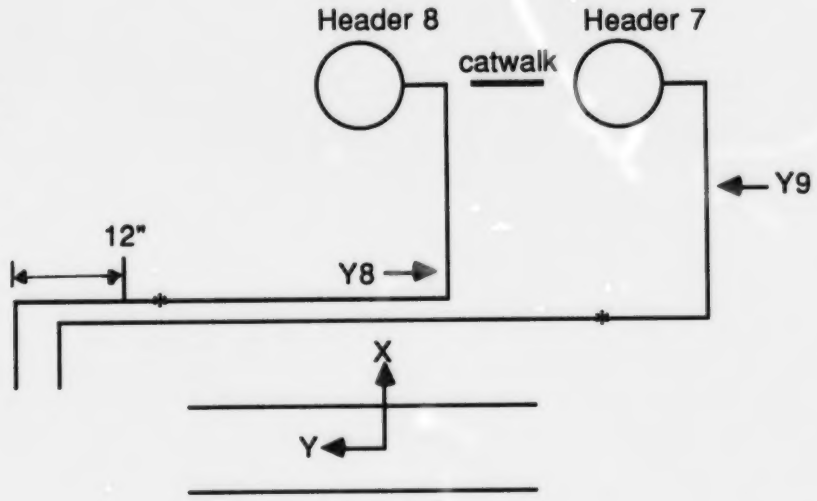
Permanent Monitoring Positions:

Lower feeders
- X8 - 75" along horizontal incline
- Y12 - 98" along horizontal incline



In feeder cabinet
- Y8 - from header 8 - on horizontal run under header
- Y9 - from header 7 - locations underneath catwalk between header 7 & 8

* accelerometer



C9 -
C12 -
on vertical just below incline - just at lower lip of feeder cabinet

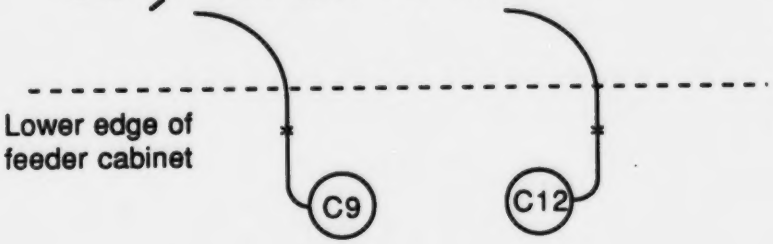


FIGURE 2

DETAILED SKETCHES OF ACCELEROMETER LOCATIONS

SIGNAL : Y8E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	41.3	4.53
2	10.3	3.65
3	5.2	3.45
4	69.8	3.00
5	74.9	2.86
6	129.2	1.85
7	118.8	1.62
8	90.4	0.70
9	54.3	0.60
10	193.8	0.60

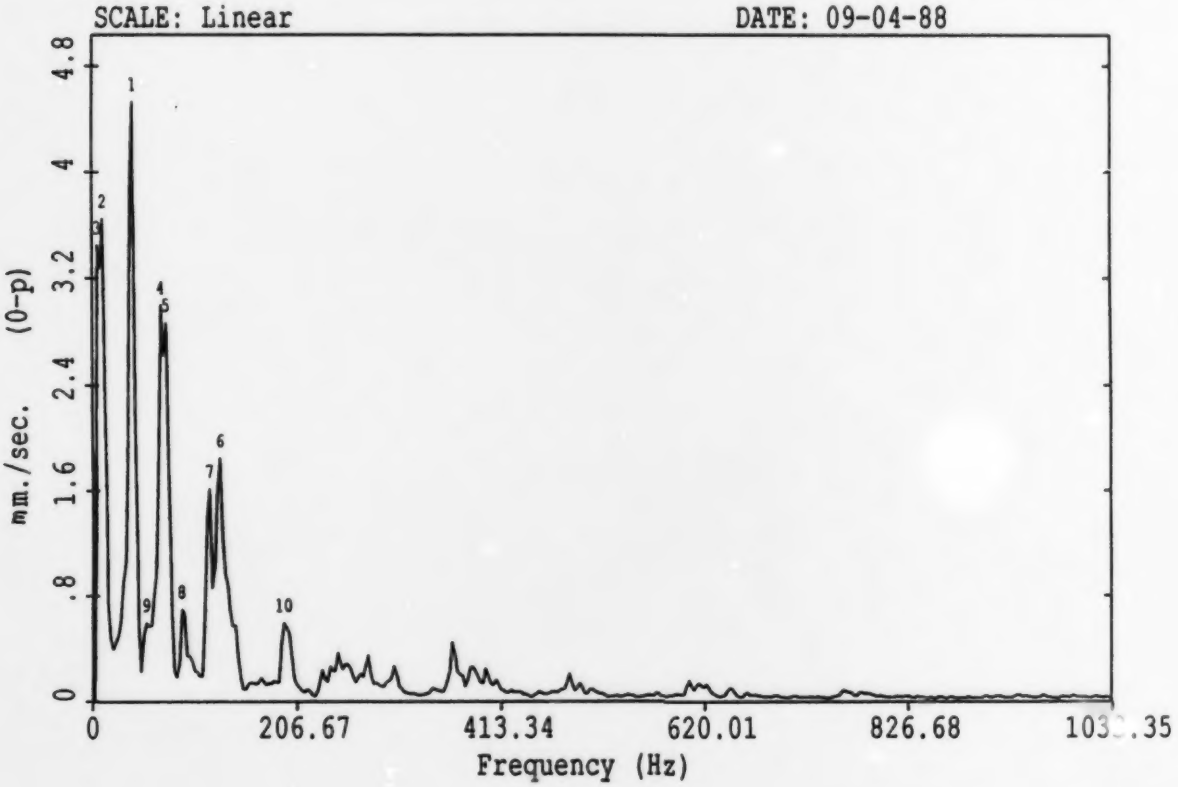


FIGURE 3
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y8E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	10.3	9.53
2	69.8	3.48
3	33.6	1.72
4	38.8	1.60
5	90.4	1.22
6	46.5	1.00
7	118.8	0.95
8	82.7	0.92
9	232.5	0.70
10	157.6	0.50

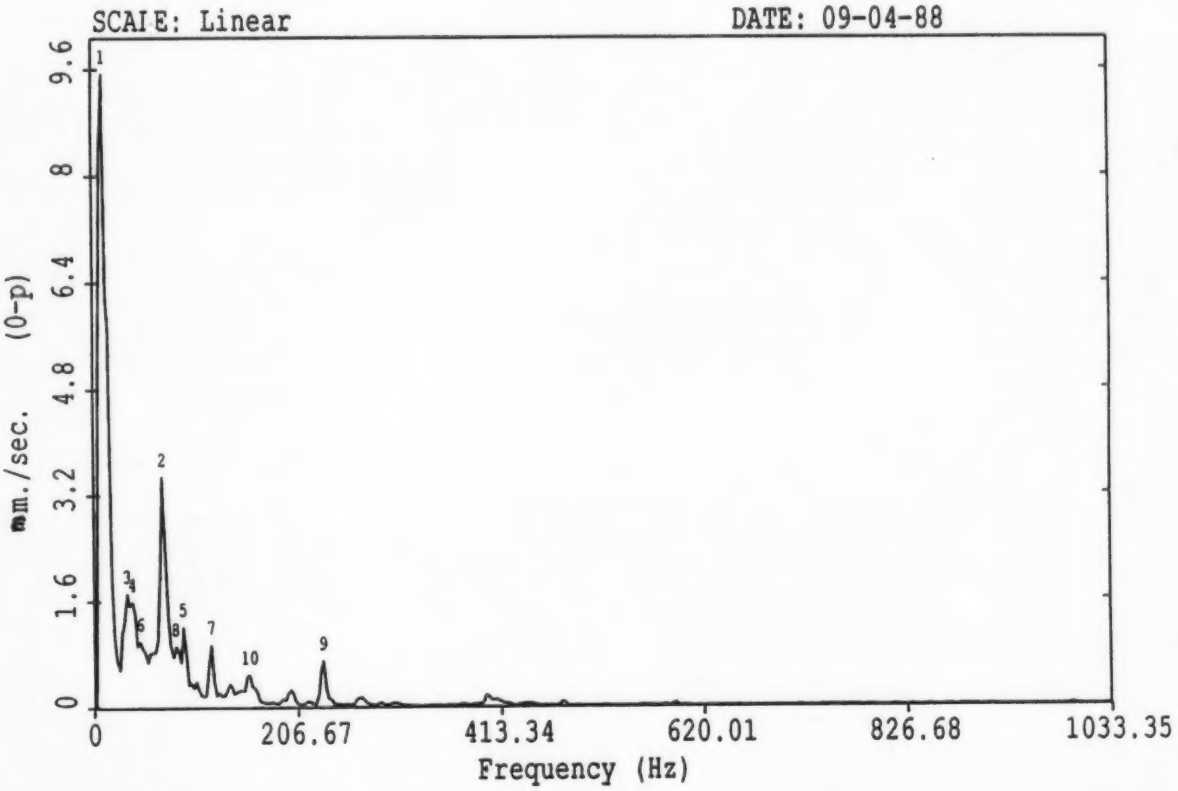


FIGURE 4
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y8E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	33.6	20.12
2	69.8	8.39
3	157.6	2.43
4	5.2	1.97
5	126.6	1.83
6	121.4	1.60
7	113.7	1.23
8	232.5	1.08
9	142.1	0.85
10	242.8	0.71

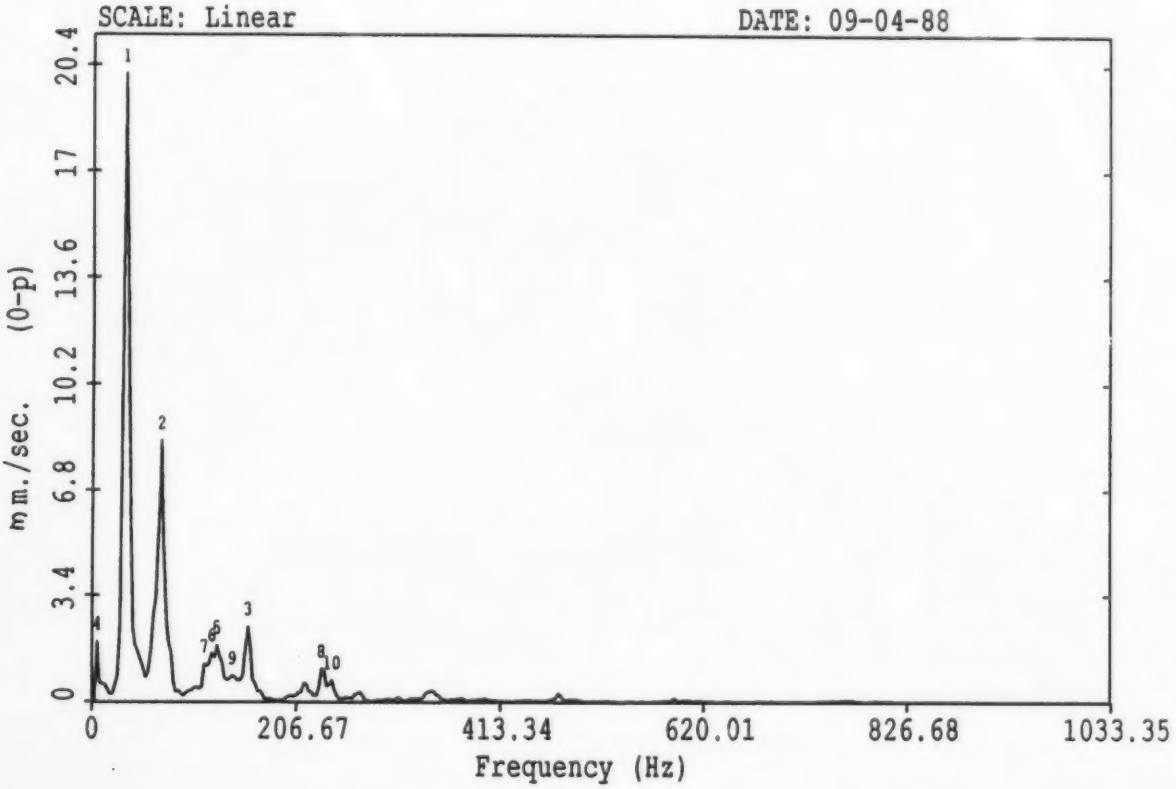


FIGURE 5
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y9E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	9.61
2	397.8	5.05
3	15.5	2.07
4	80.1	1.17
5	59.4	0.86
6	38.8	0.55
7	46.5	0.49
8	31.0	0.49
9	260.9	0.38
10	240.3	0.37

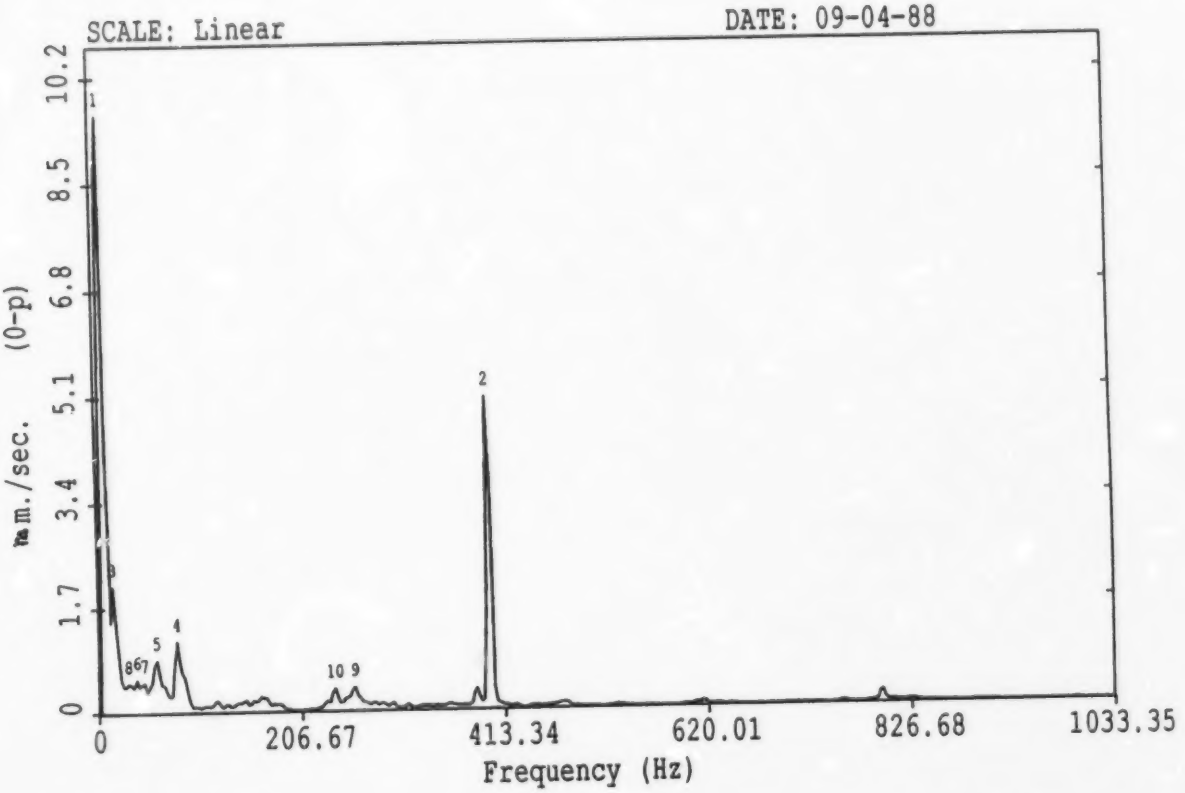


FIGURE 6
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y9E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	3.78
2	33.6	2.11
3	54.3	0.65
4	397.8	0.64
5	69.8	0.35
6	80.1	0.21
7	299.7	0.20
8	113.7	0.19
9	87.8	0.17
10	118.8	0.14

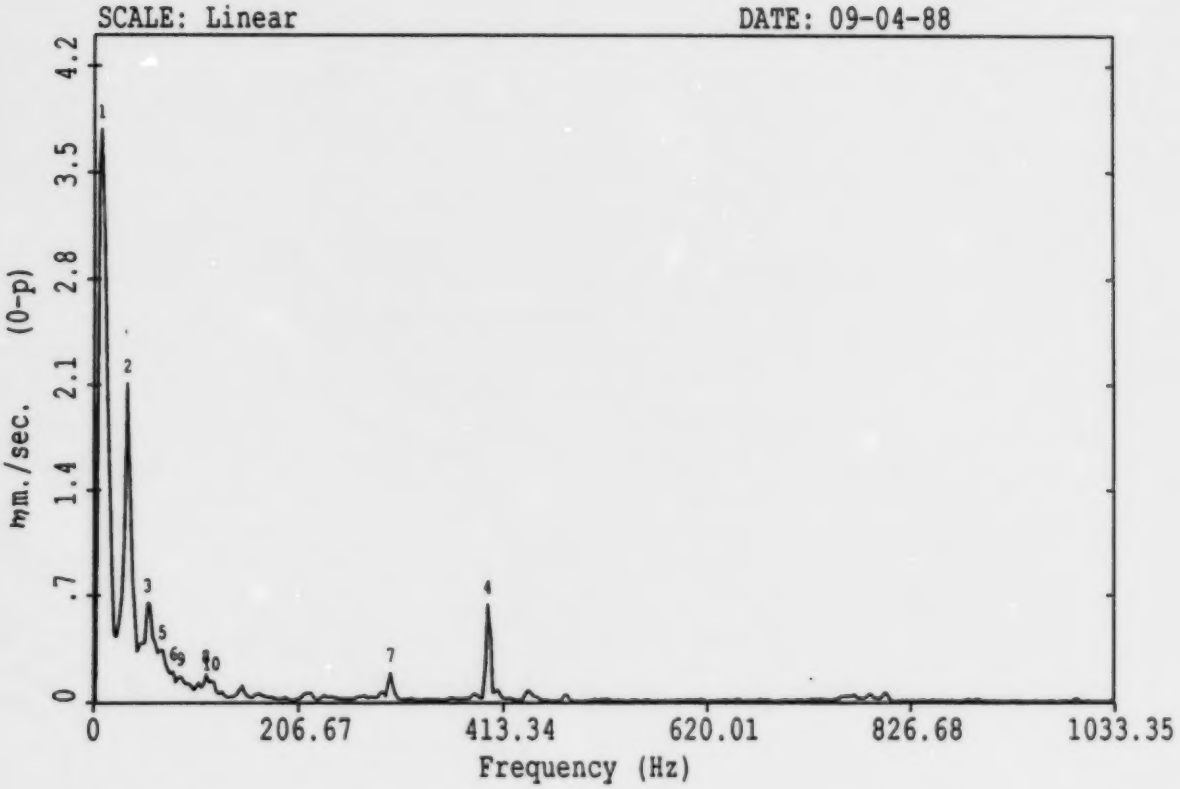


FIGURE 7
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

178321-RD
88-274

SIGNAL : Y9E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	10.3	15.46
2	54.3	3.33
3	33.6	2.86
4	397.8	1.63
5	80.1	1.37
6	67.2	1.02
7	43.9	0.76
8	165.3	0.63

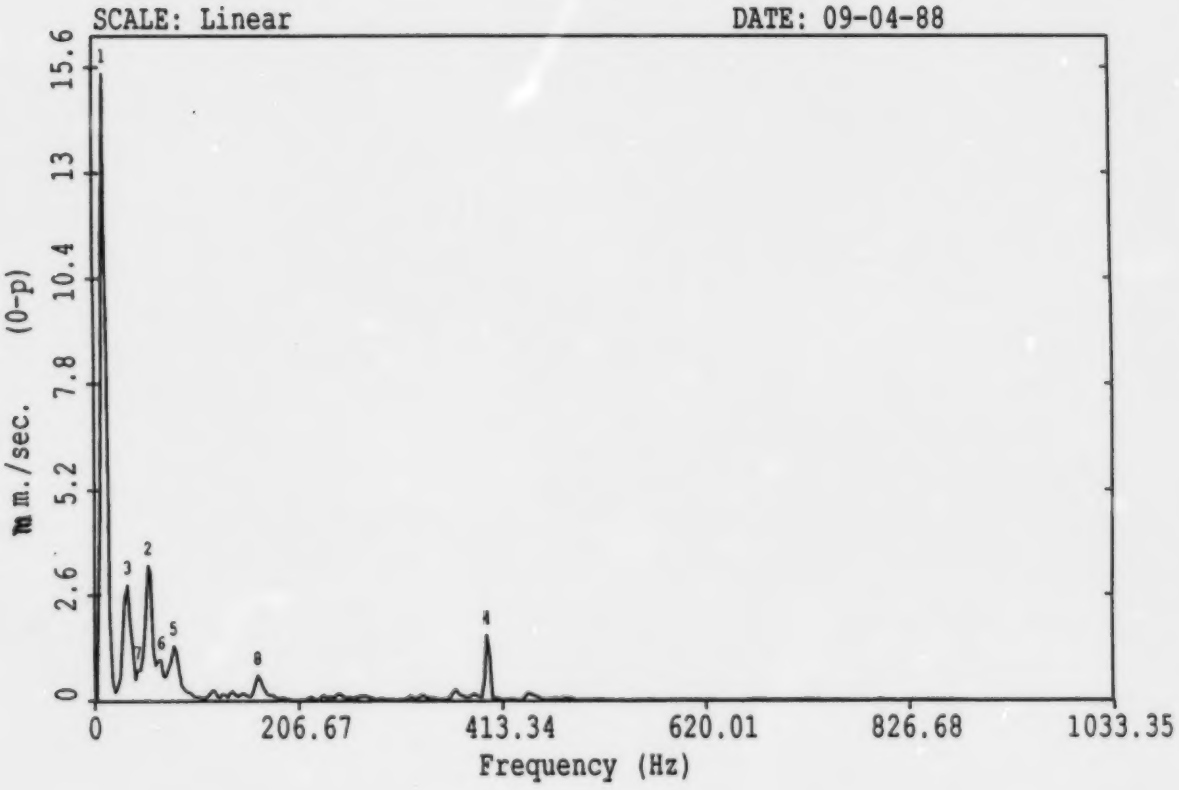


FIGURE 8
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C12E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	397.8	11.00
2	12.9	3.91
3	5.2	3.02
4	31.0	1.21
5	56.8	1.14
6	36.2	1.01
7	798.3	0.59
8	410.8	0.39
9	98.2	0.38
10	87.8	0.31

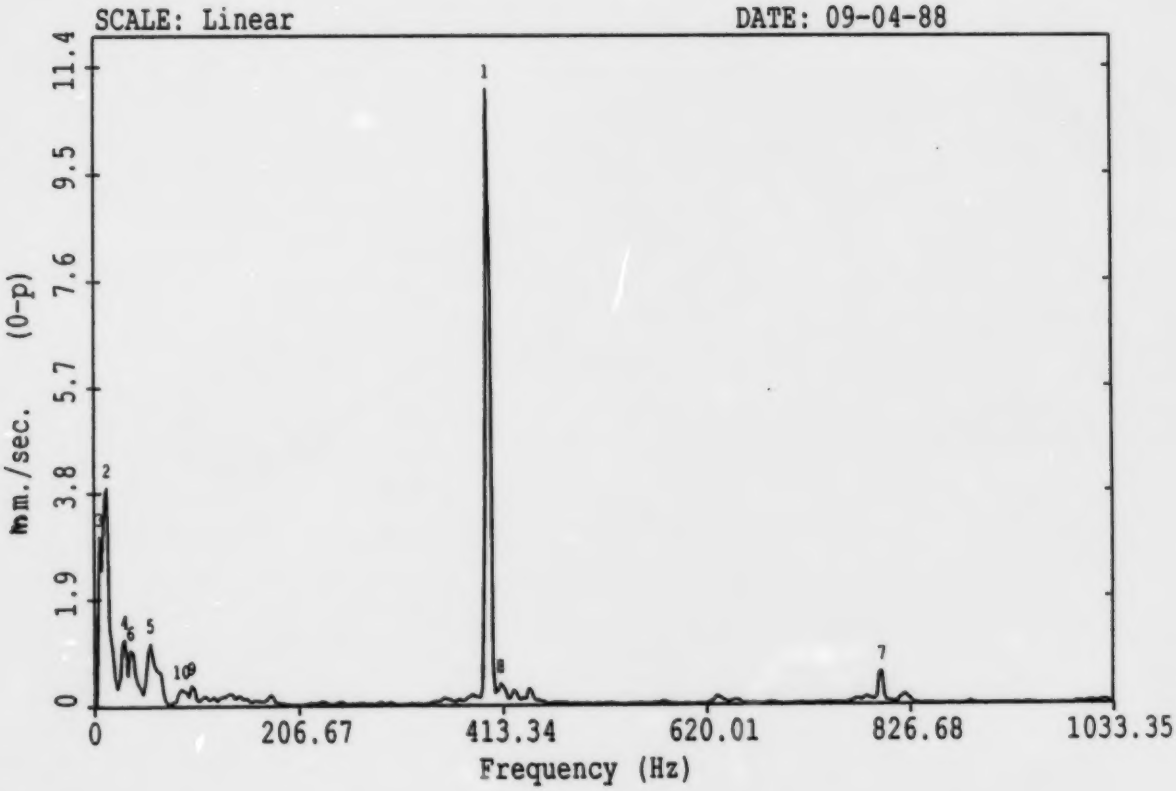


FIGURE 9
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C12E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	397.8	12.61
2	12.9	2.41
3	59.4	0.59
4	5.2	0.59
5	98.2	0.32
6	67.2	0.31
7	426.3	0.29

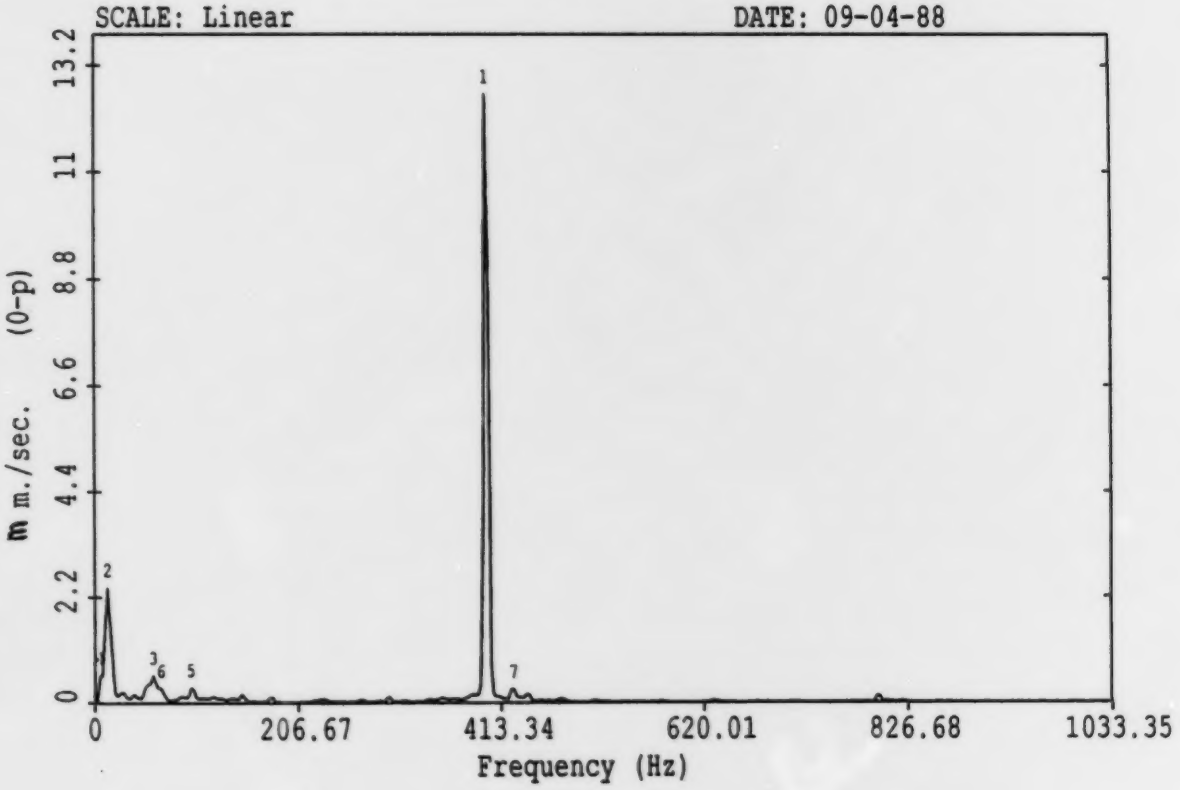


FIGURE 10
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C12E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	397.8	10.42
2	31.0	4.70
3	56.8	2.93
4	5.2	2.30
5	12.9	2.30
6	64.6	2.26
7	38.8	1.55
8	121.4	0.53
9	149.8	0.47
10	87.8	0.47

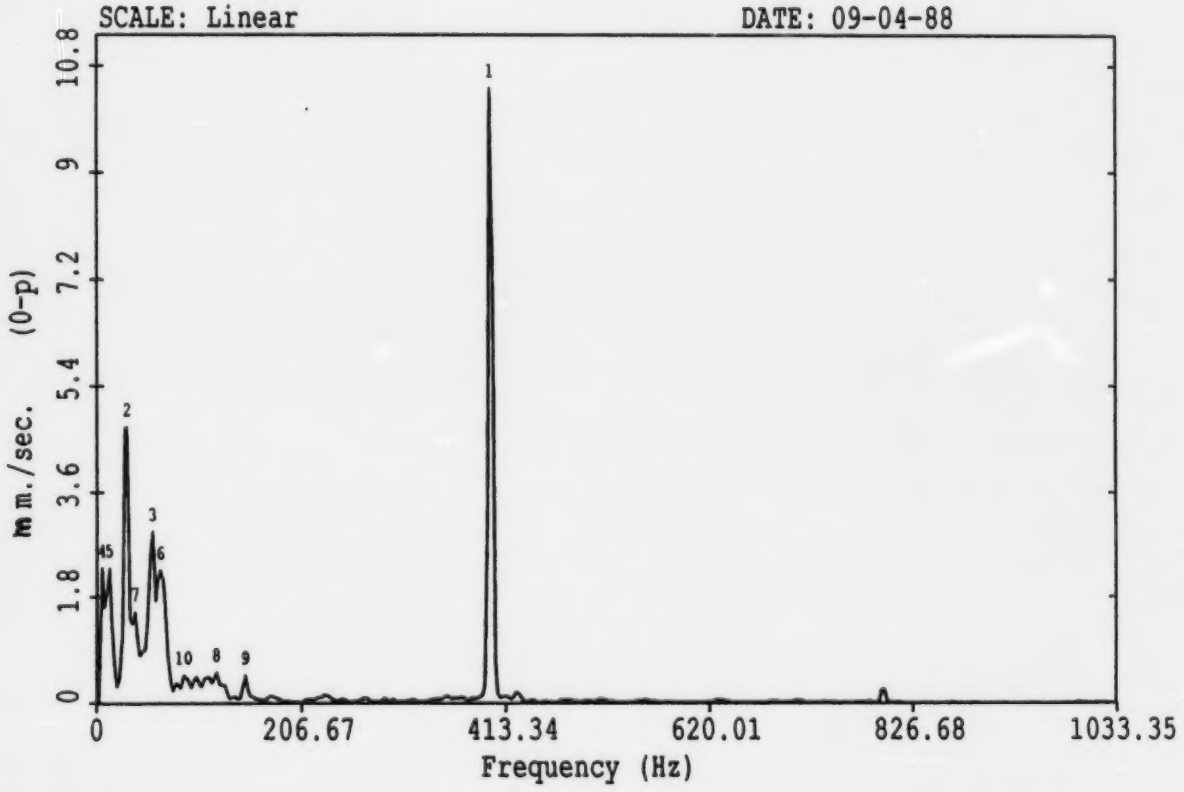


FIGURE 11
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C9E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	7.60
2	12.9	4.60
3	33.6	3.63
4	77.5	2.00
5	25.8	1.73
6	95.6	1.63
7	134.3	1.34
8	111.1	0.80
9	397.8	0.70
10	315.2	0.45

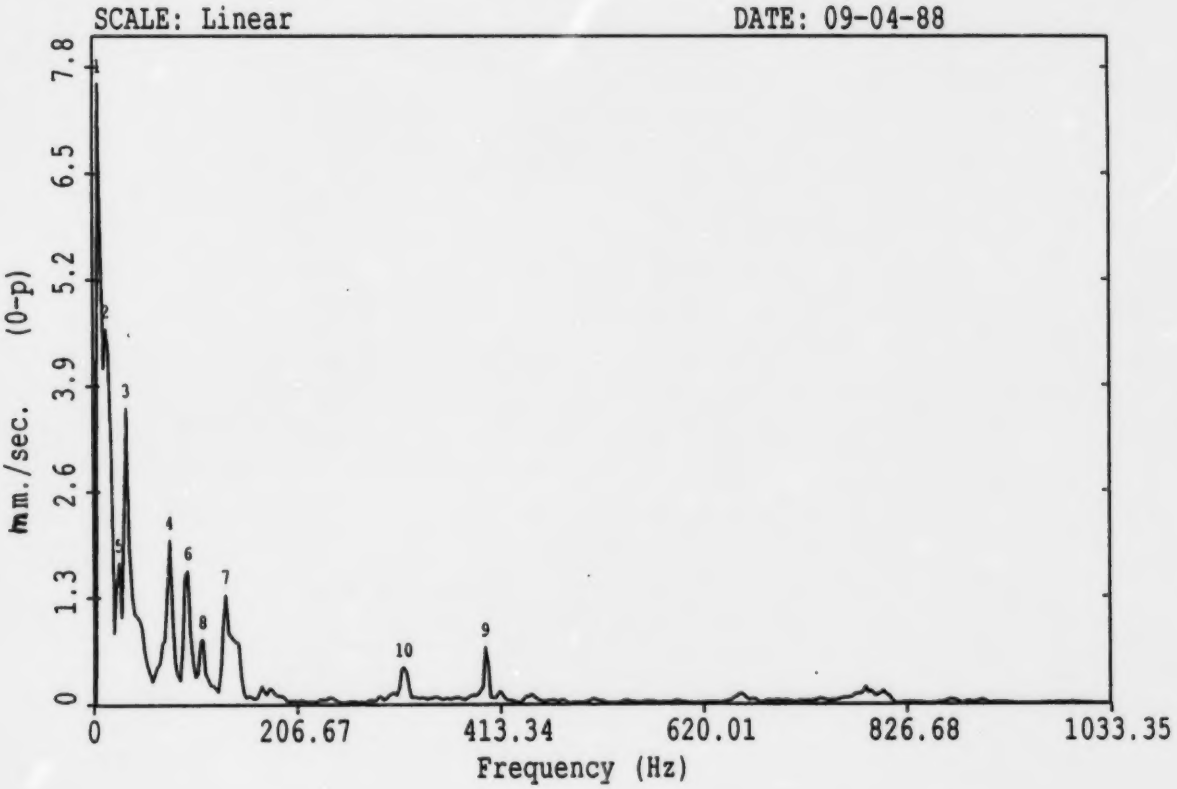


FIGURE 12
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

178326-RD
88-274

SIGNAL : C9E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	18.1	1.55
2	93.0	1.13
3	38.8	0.67
4	397.8	0.65
5	46.5	0.57
6	312.6	0.49
7	105.9	0.45
8	5.2	0.41
9	160.2	0.37
10	77.5	0.32

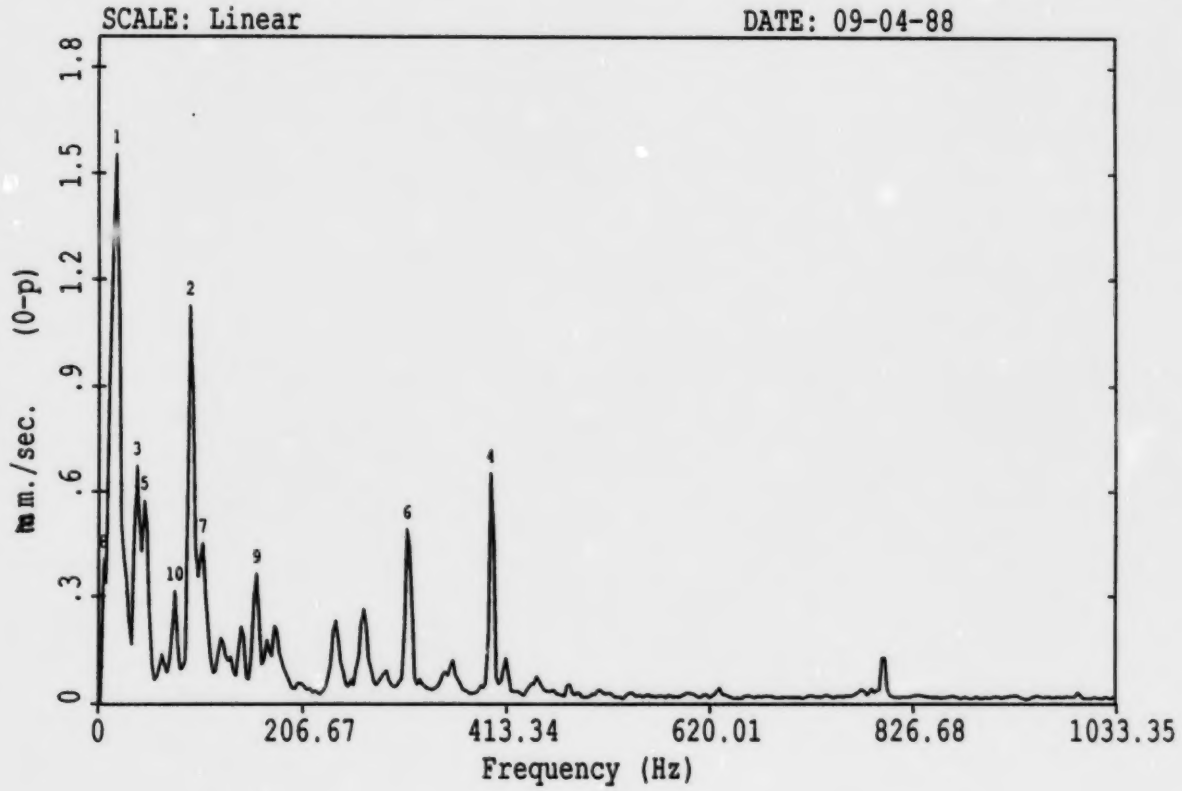


FIGURE 13
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C9E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 1 & 3

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	33.6	5.74
2	5.2	5.21
3	46.5	4.11
4	23.3	2.69
5	15.5	2.10
6	64.6	1.23
7	105.9	1.13
8	397.8	0.79
9	72.3	0.69
10	87.8	0.62

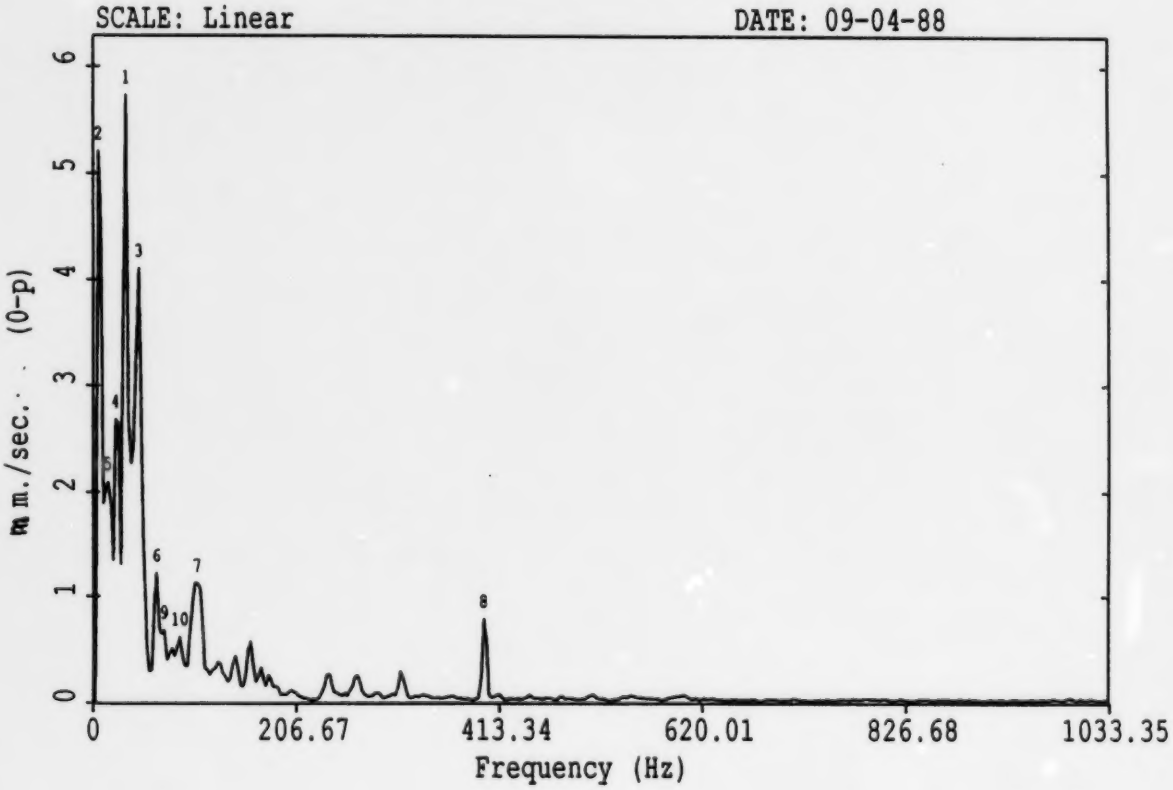


FIGURE 14
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : X8E Transverse
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	17.30
2	33.6	1.95
3	149.8	1.47
4	25.8	0.87
5	299.7	0.77
6	46.5	0.64
7	142.1	0.63
8	59.4	0.62
9	90.4	0.59
10	108.5	0.46

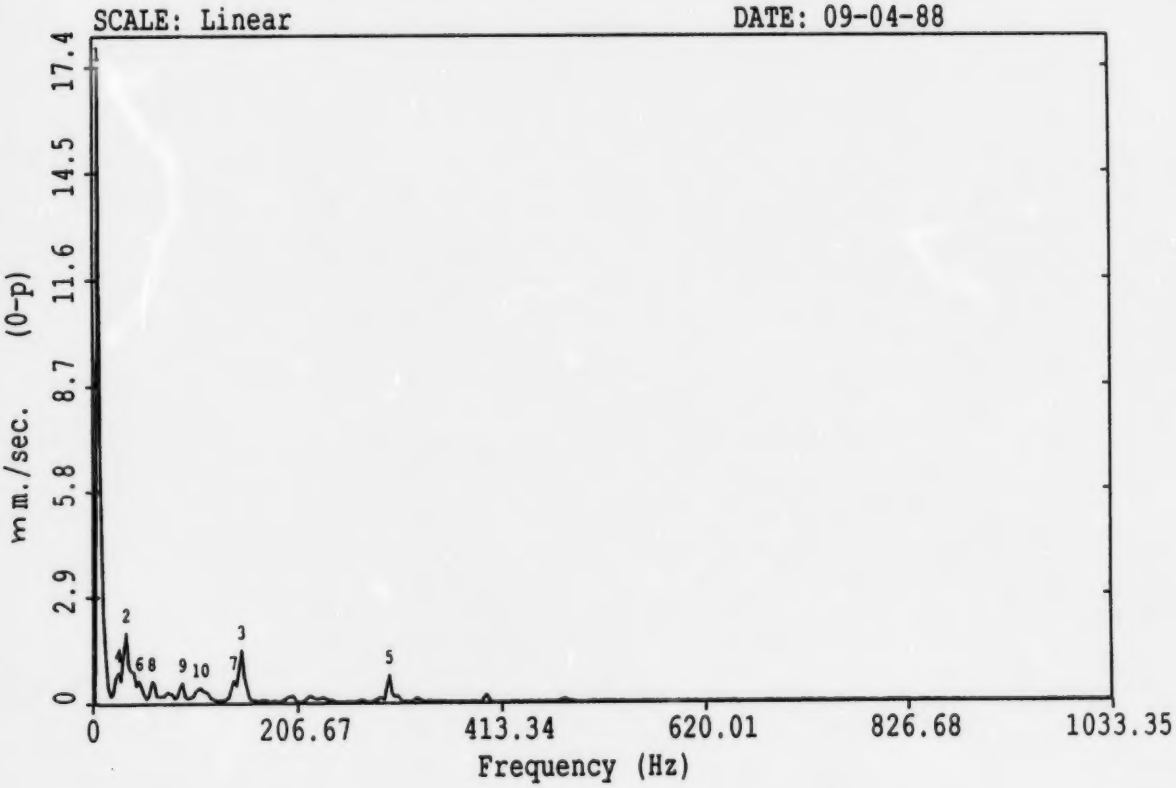


FIGURE 15
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : X8E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	3.03
2	36.2	1.10
3	149.8	0.98
4	67.2	0.46
5	397.8	0.32
6	51.7	0.26
7	105.9	0.13
8	100.8	0.12
9	129.2	0.09
10	87.8	0.09

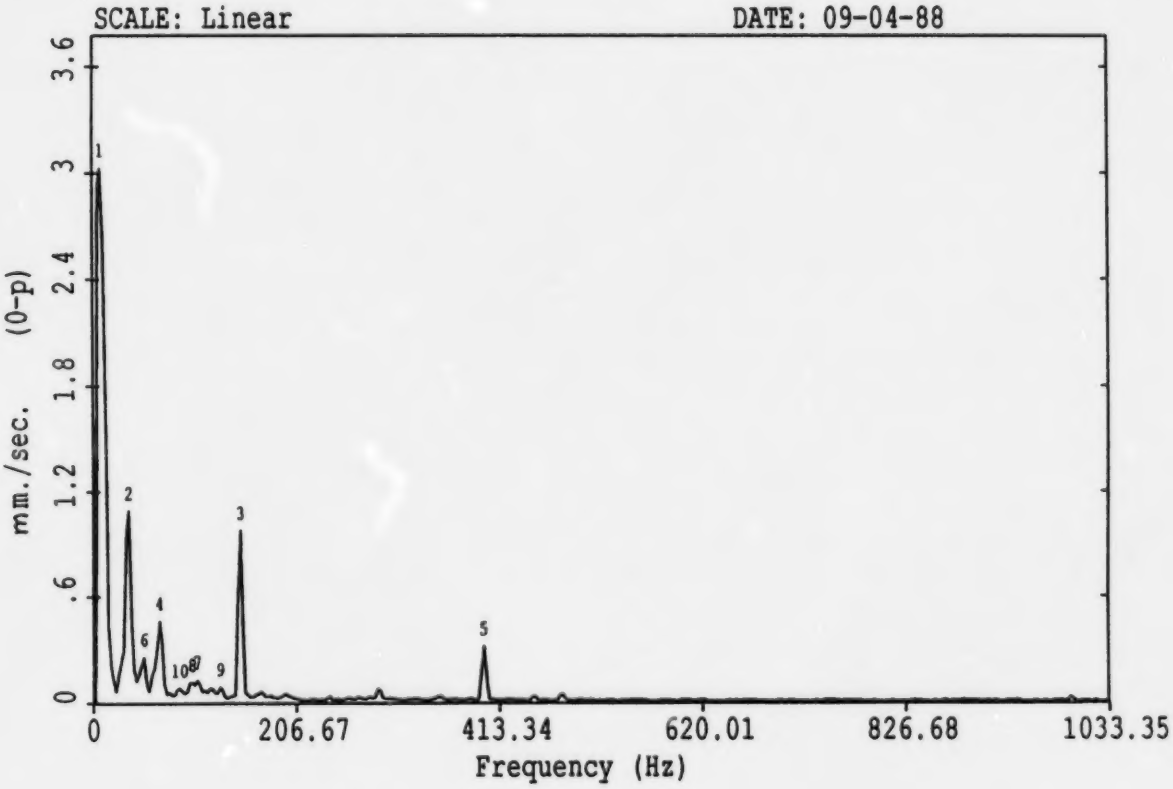


FIGURE 16
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : X8E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	9.93
2	149.8	4.37
3	36.2	2.47
4	28.4	1.17
5	67.2	0.54
6	59.4	0.51
7	139.5	0.45
8	85.3	0.41
9	98.2	0.31
10	121.4	0.22

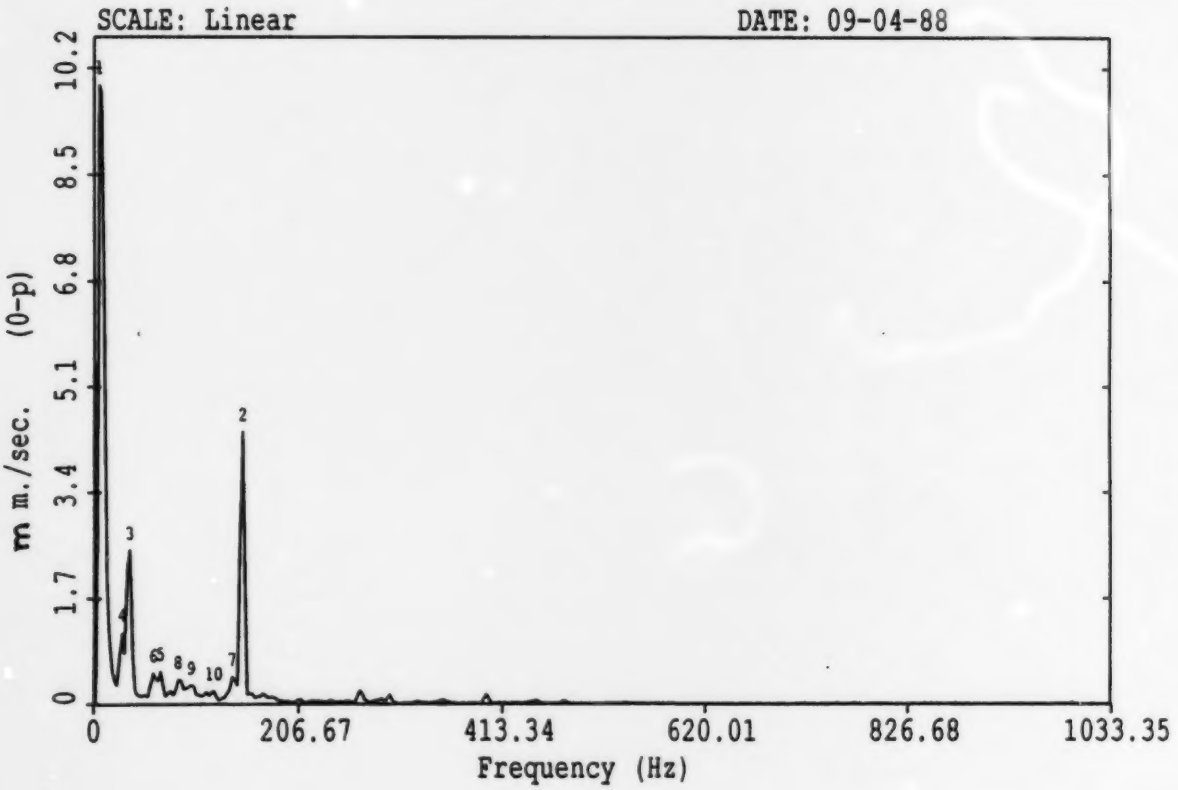


FIGURE 17
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y12E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	15.45
2	149.8	14.10
3	299.7	2.89
4	217.0	2.01
5	49.1	1.98
6	12.9	1.97
7	41.3	1.43
8	240.3	1.13
9	67.2	1.05
10	20.7	0.93

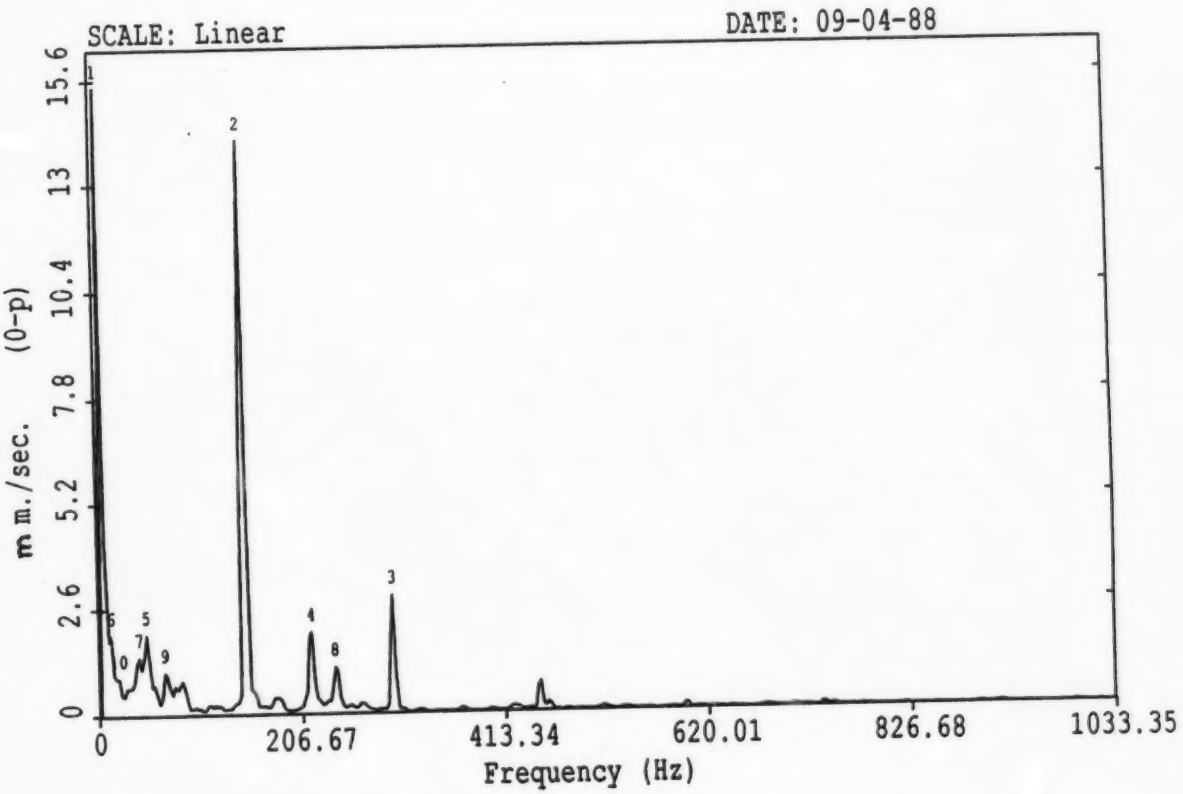


FIGURE 18
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y12E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	10.3	6.92
2	149.8	5.22
3	33.6	0.71
4	49.1	0.64
5	25.8	0.62
6	299.7	0.61
7	20.7	0.60
8	74.9	0.57
9	90.4	0.30
10	113.7	0.20

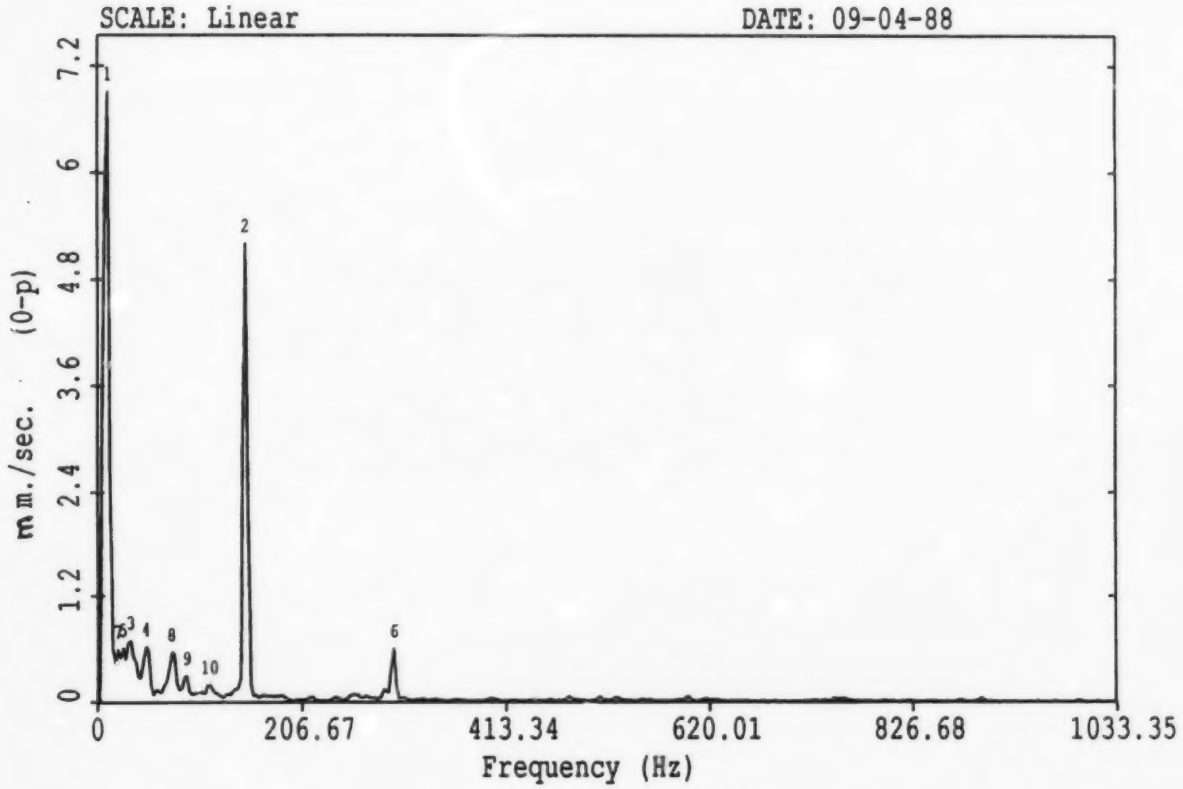


FIGURE 19
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : Y12E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	19.59
2	149.8	6.66
3	38.8	2.86
4	299.7	1.61
5	20.7	1.17
6	64.6	1.09
7	49.1	1.01
8	136.9	0.75
9	31.0	0.71
10	90.4	0.65

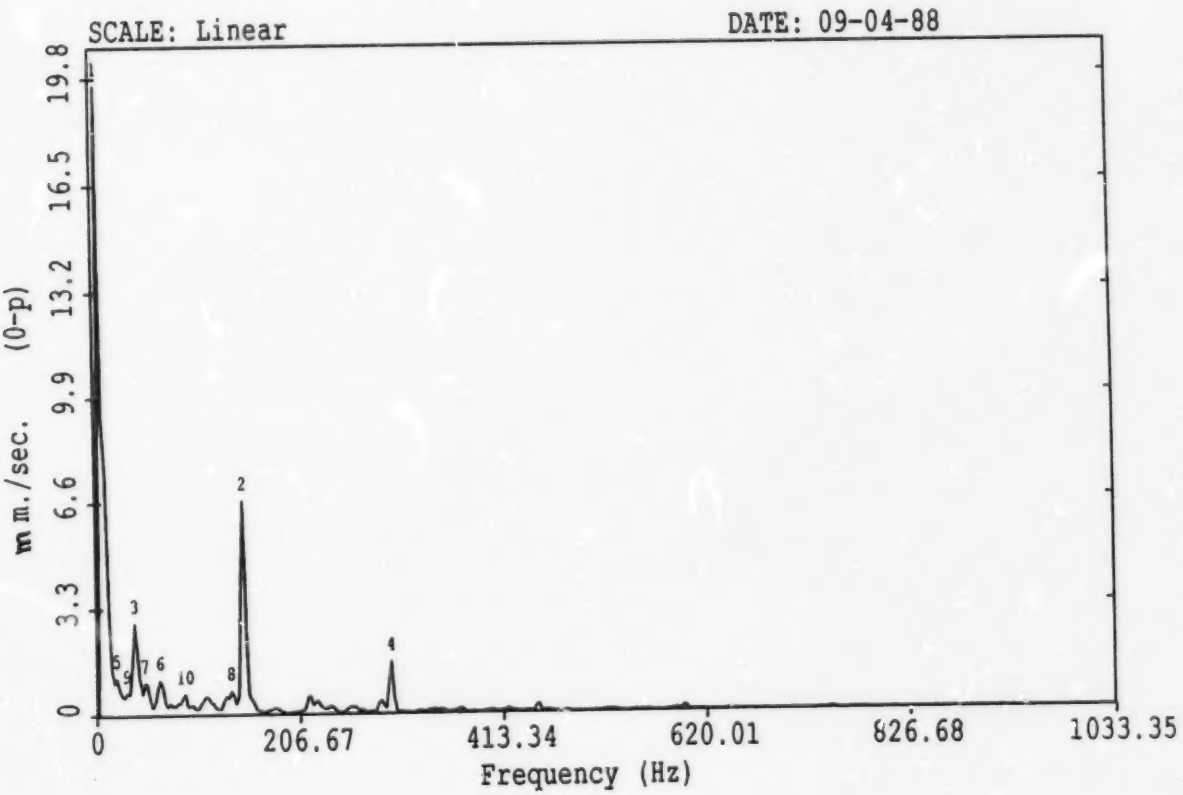


FIGURE 20
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

178334-RD

88-274

SIGNAL : C12E TRANSVERSE
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	5.2	6.49
2	12.9	4.05
3	149.8	1.21
4	397.8	0.71
5	38.8	0.61
6	87.8	0.58
7	54.3	0.41
8	67.2	0.38
9	224.8	0.26
10	31.0	0.17

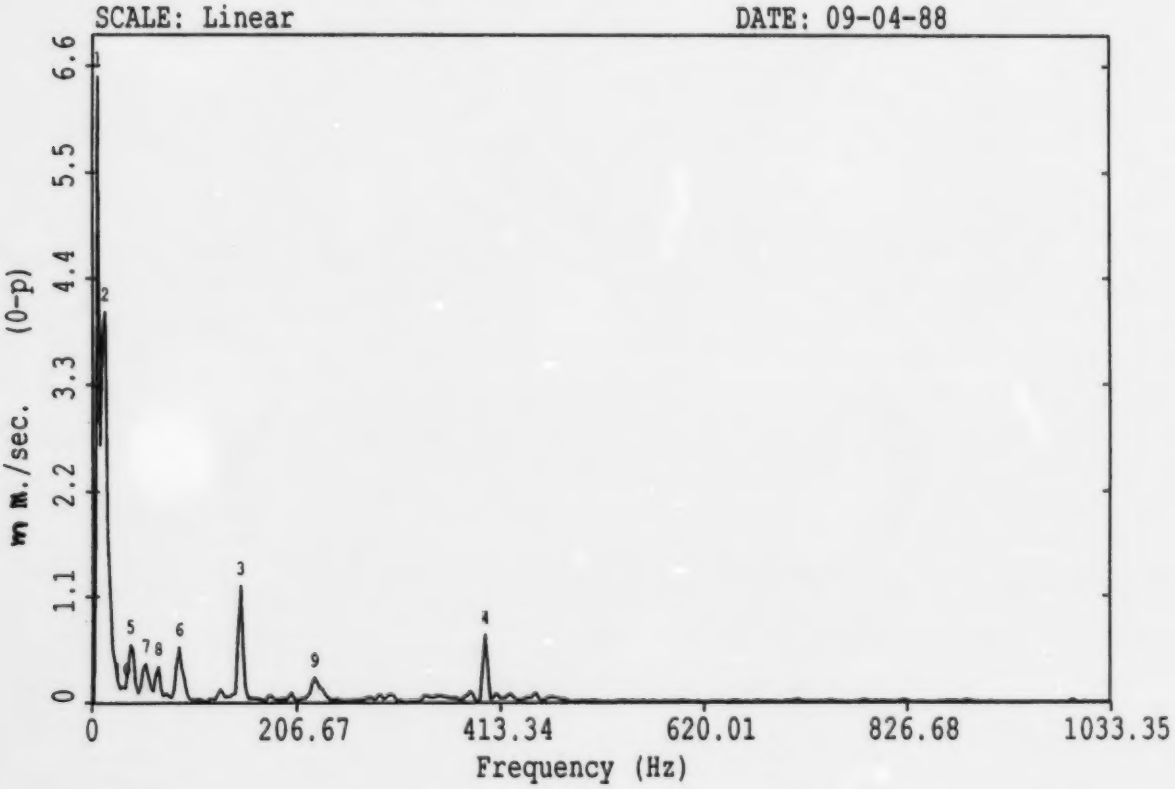


FIGURE 21
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

178335-RD

SIGNAL : C12E AXIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	5.94
2	31.0	1.75
3	397.8	0.54
4	56.8	0.23
5	41.3	0.20
6	95.6	0.18
7	87.8	0.14

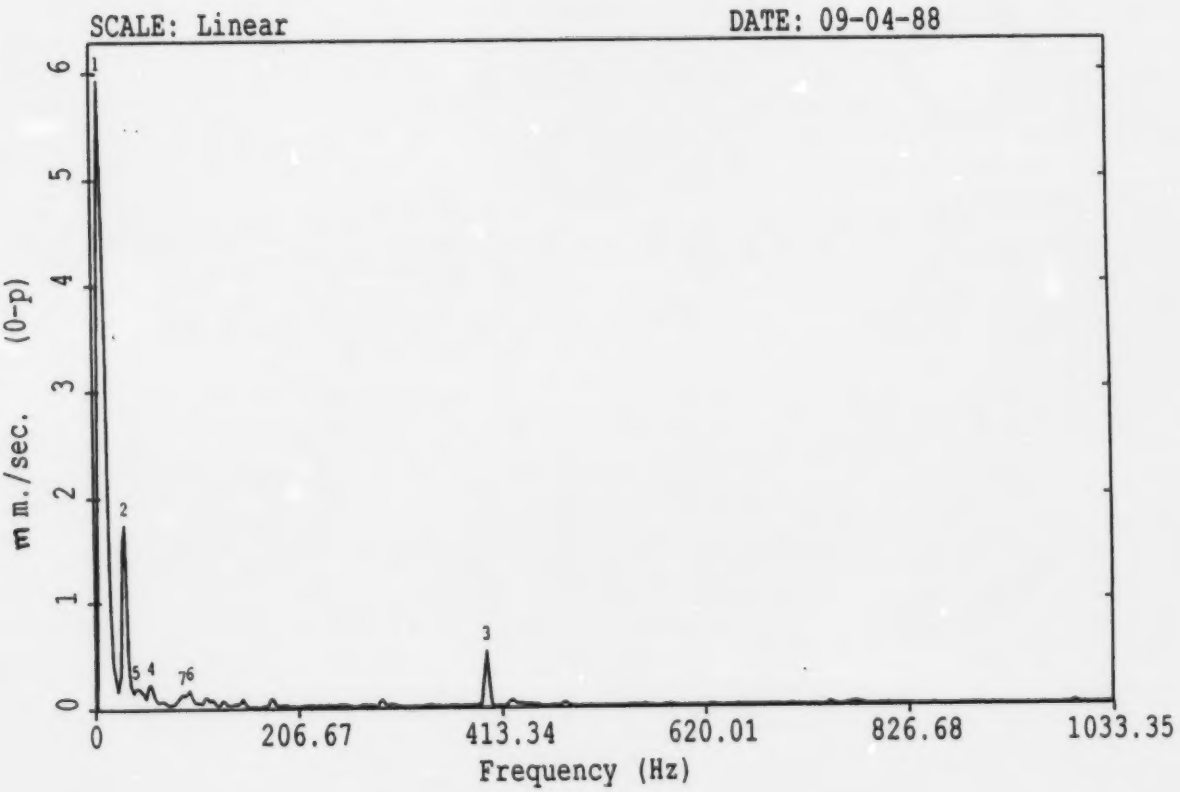


FIGURE 22
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

SIGNAL : C12E RADIAL
PROCESS CONDITION : Cold Conditioning PUMPS 2 & 4

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	10.3	9.04
2	87.8	1.87
3	36.2	1.24
4	149.8	0.58
5	397.8	0.51
6	54.3	0.42
7	23.3	0.40
8	178.3	0.24

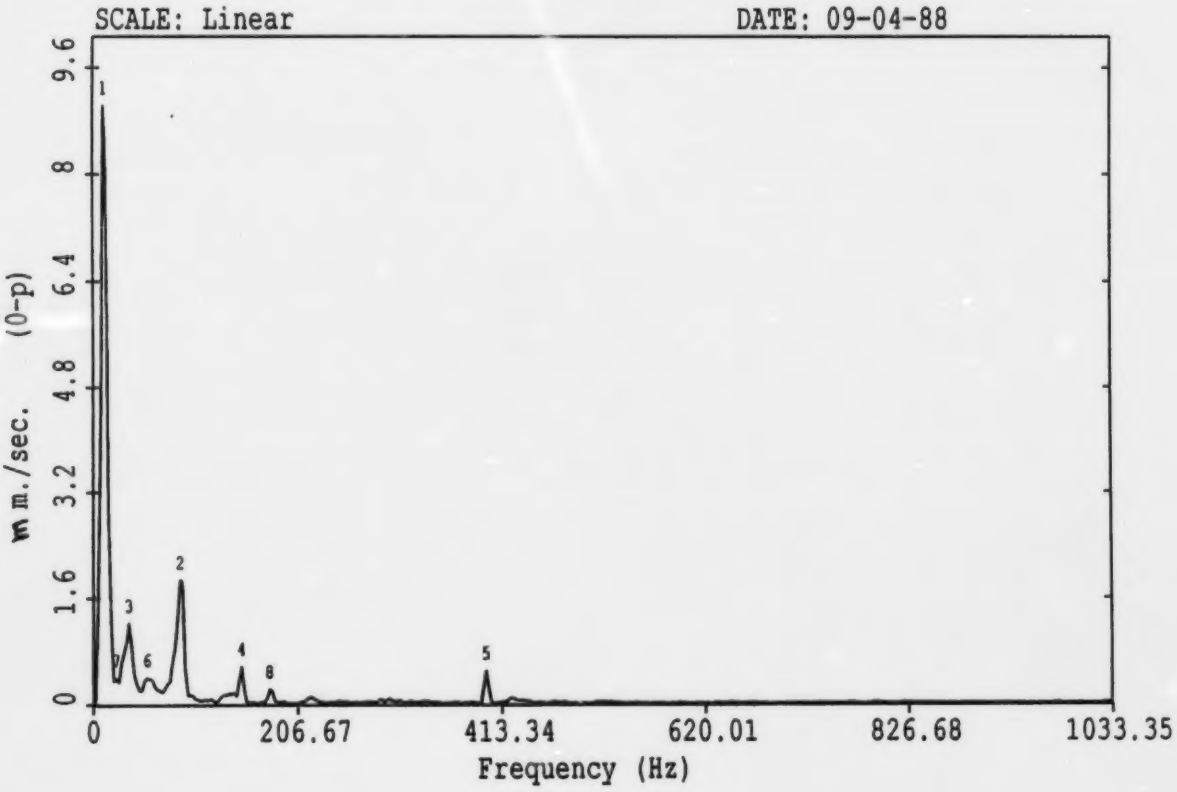


FIGURE 23
DARLINGTON NGS UNIT 2 FEEDER VIBRATION

178337-RD

SIGNAL : C12E Transverse Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 1 & 3 on, Pump 4 Turbining
T = 260°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	390.1	3.08
2	7.8	2.67
3	149.8	1.41
4	18.1	1.17
5	54.3	1.04
6	59.4	0.85
7	28.4	0.79
8	33.6	0.63
9	46.5	0.50
10	139.5	0.35

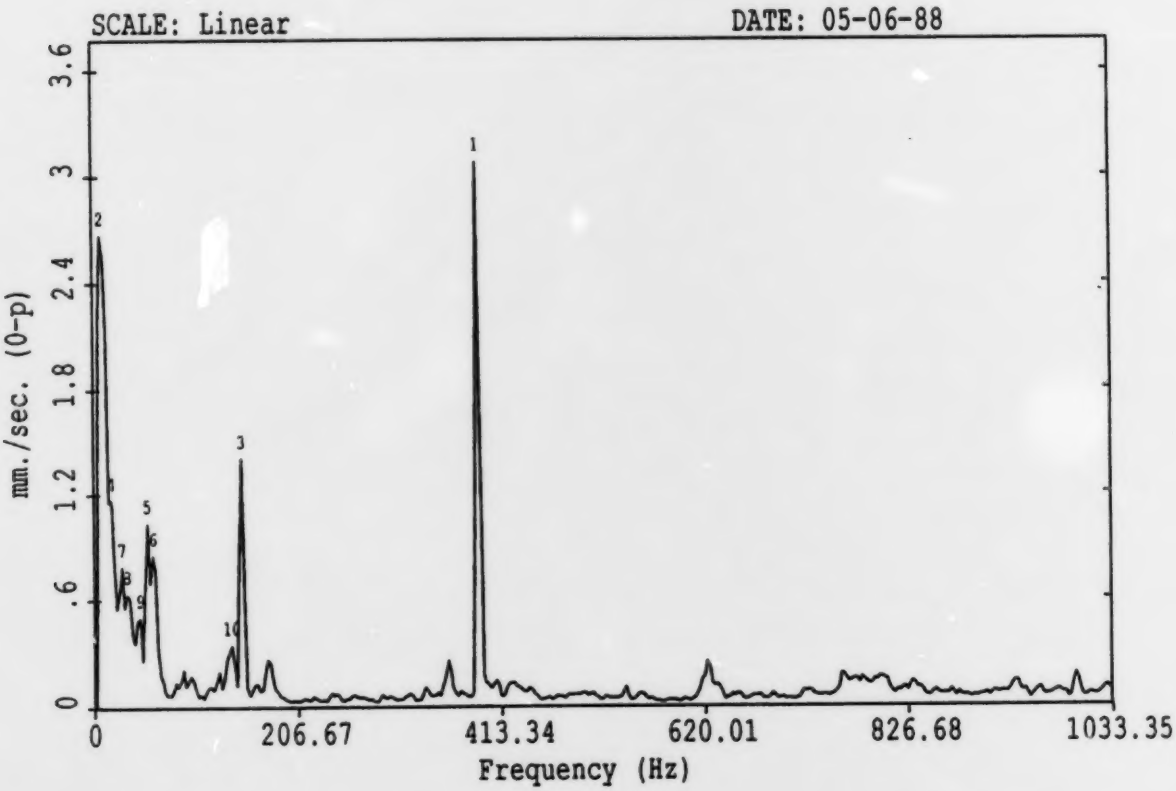


FIGURE 24
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

SIGNAL : C12E Axial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 1 & 3 on, Pump 4 Turbining
T = 260°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	390.1	9.78
2	12.9	1.38
3	59.4	0.87
4	5.2	0.68
5	149.8	0.36
6	46.5	0.26
7	28.4	0.23
8	41.3	0.23

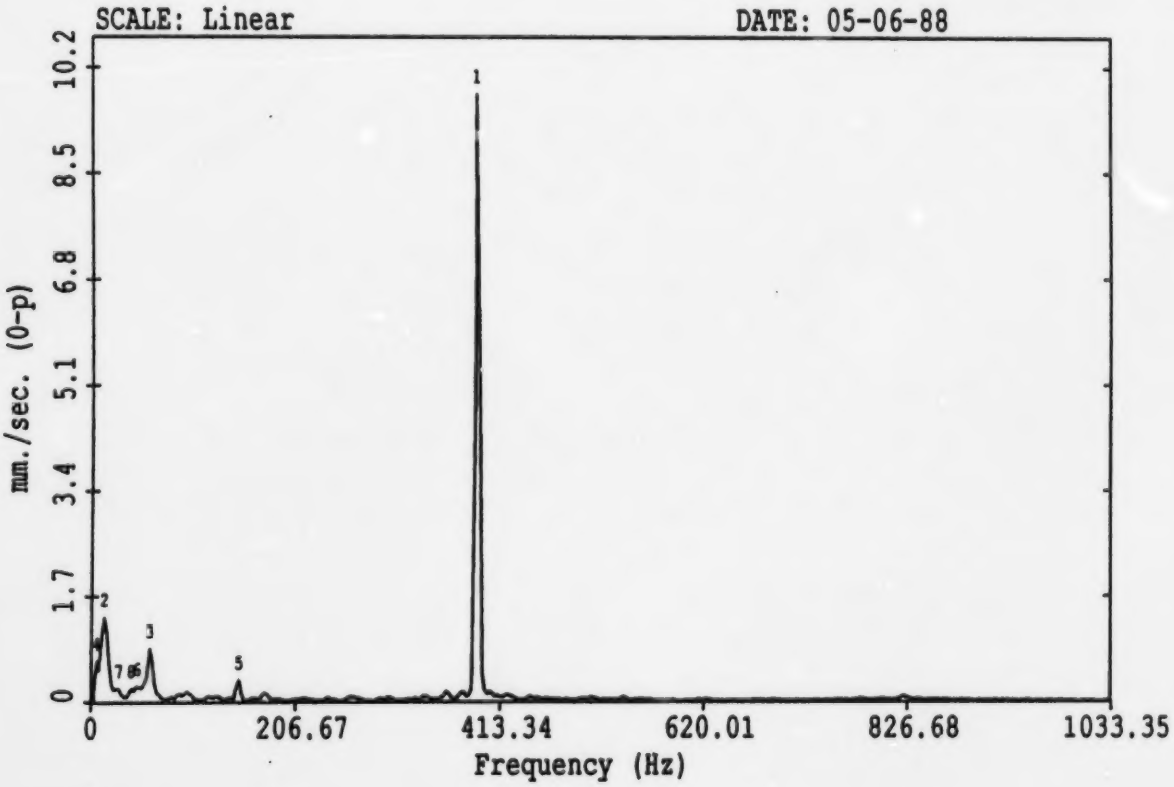


FIGURE 25
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178339-RD

SIGNAL : C12E Radial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 1 & 3 on, Pump 4 Turbining
T = 260°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	6.96
2	20.7	1.[illegible]
3	59.4	0.8[illegible]
4	90.4	0.30
5	49.1	0.24
6	124.0	0.22

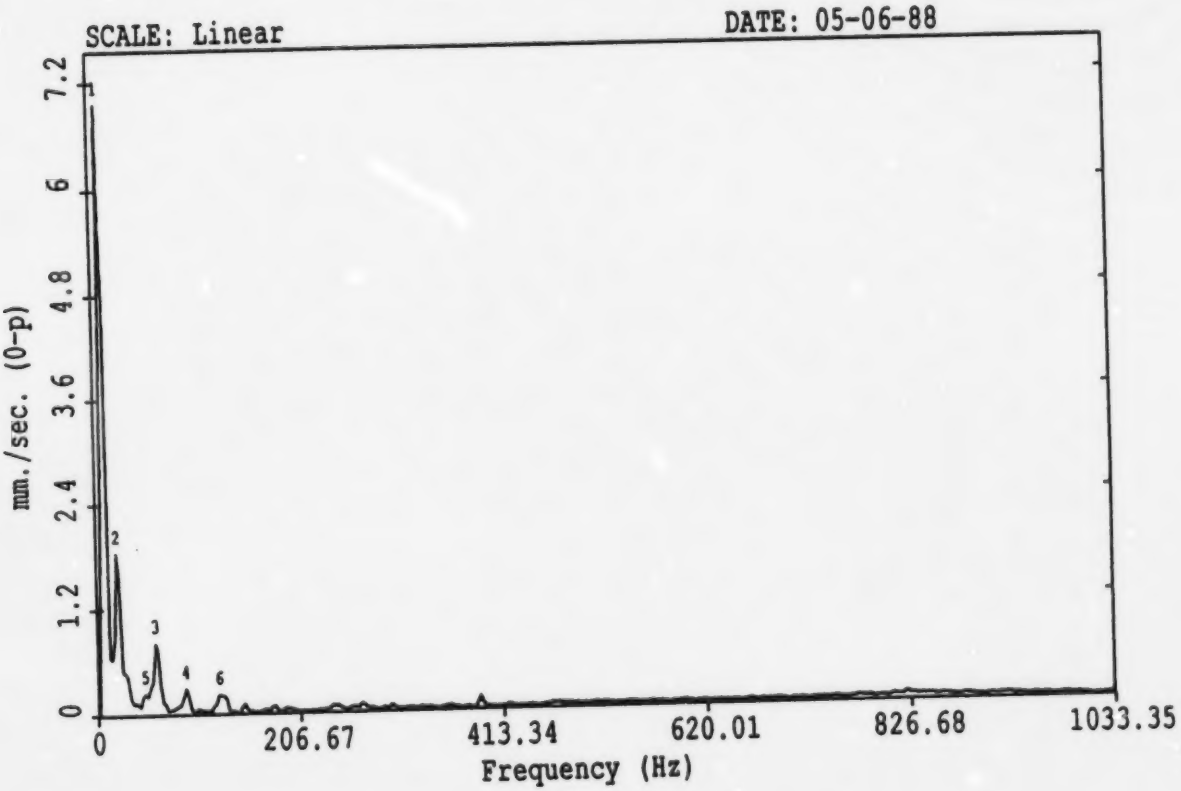


FIGURE 26

DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178340-RD

SIGNAL : ROH 7 Instr. Line radial velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 1 & 3 on, Pump 4 Turbining
T = 260°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	397.8	3.32
2	5.2	2.11
3	12.9	1.99
4	793.1	1.44
5	149.8	1.40
6	18.1	1.10
7	54.3	1.06
8	31.0	0.89
9	59.4	0.85
10	36.2	0.72

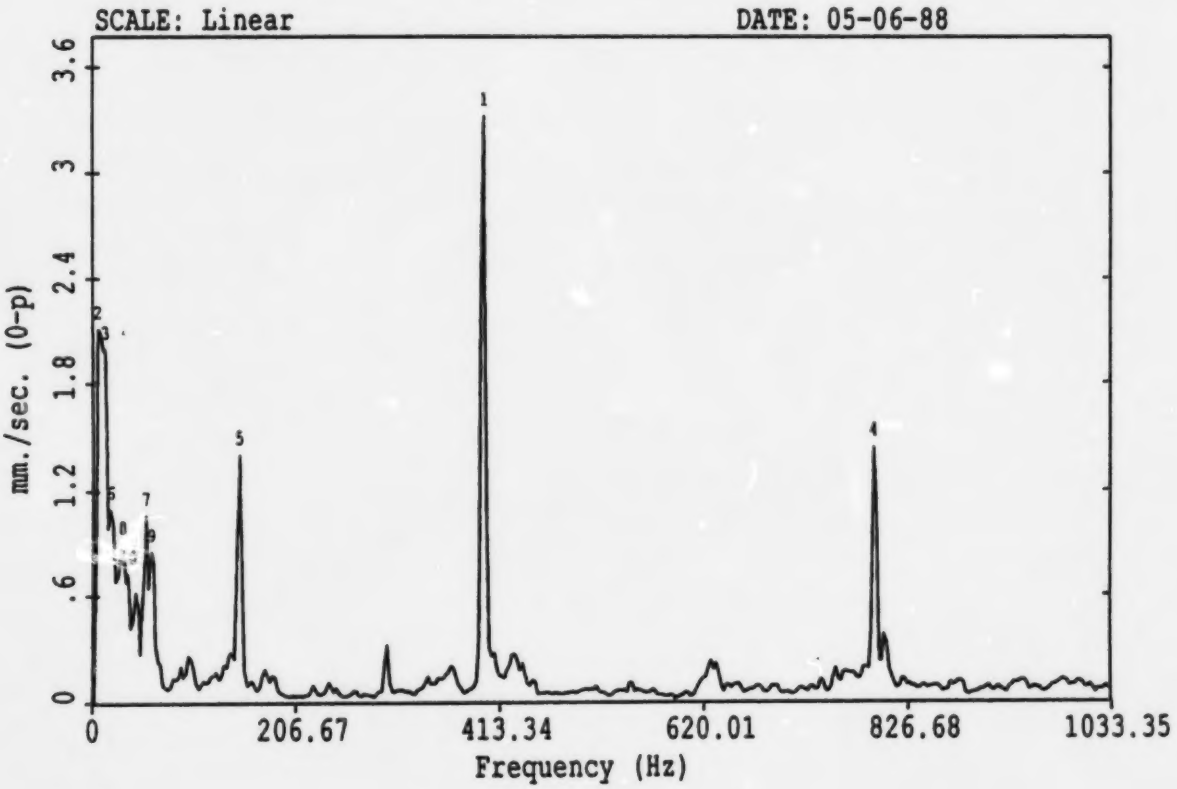


FIGURE 27
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178341-RD

88-274

SIGNAL : C12E Transverse Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	397.8	7.37
2	10.3	1.25
3	59.4	0.97
4	299.7	0.40
5	46.5	0.28
6	149.8	0.26
7	98.2	0.23
8	793.1	0.22
9	341.0	0.20

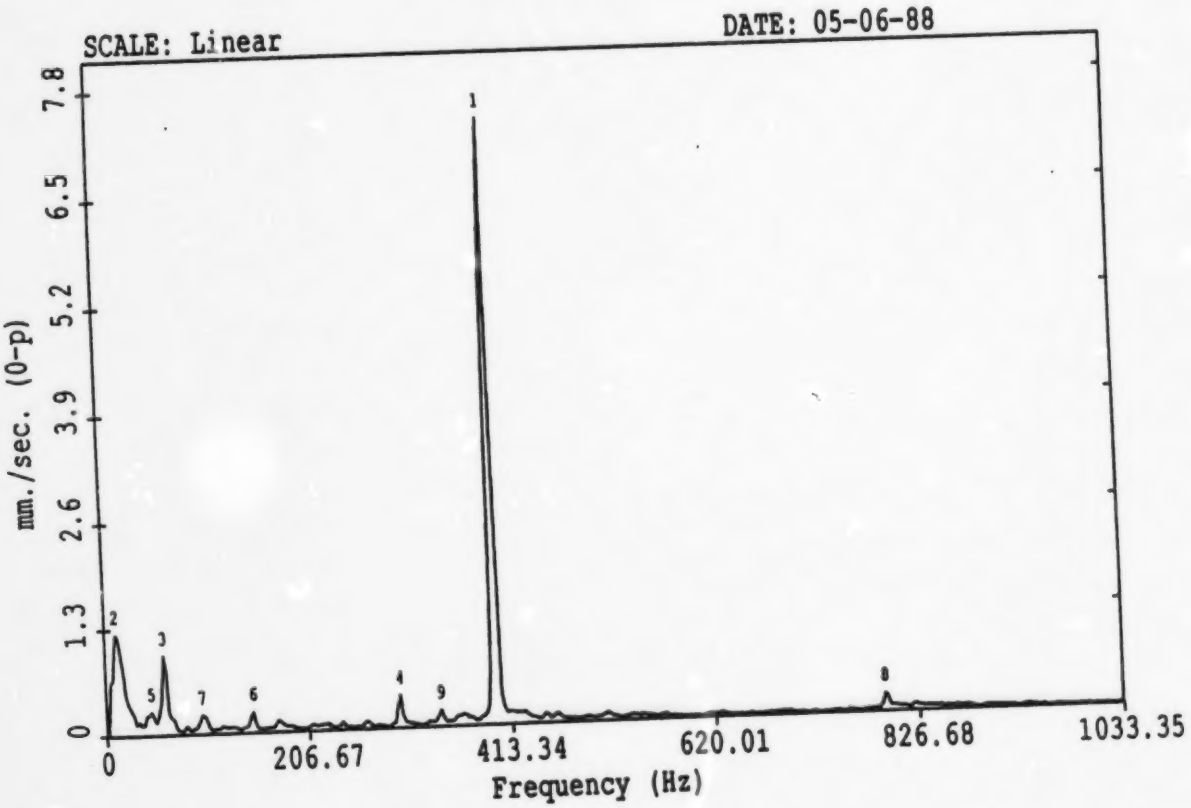


FIGURE 28

DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178342-RD

SIGNAL : C12E Axial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	28.4	3.66
2	10.3	2.14
3	54.3	2.02
4	397.8	1.87
5	36.2	0.90
6	67.2	0.65
7	149.8	0.50
8	793.1	0.37
9	299.7	0.33
10	121.4	0.30

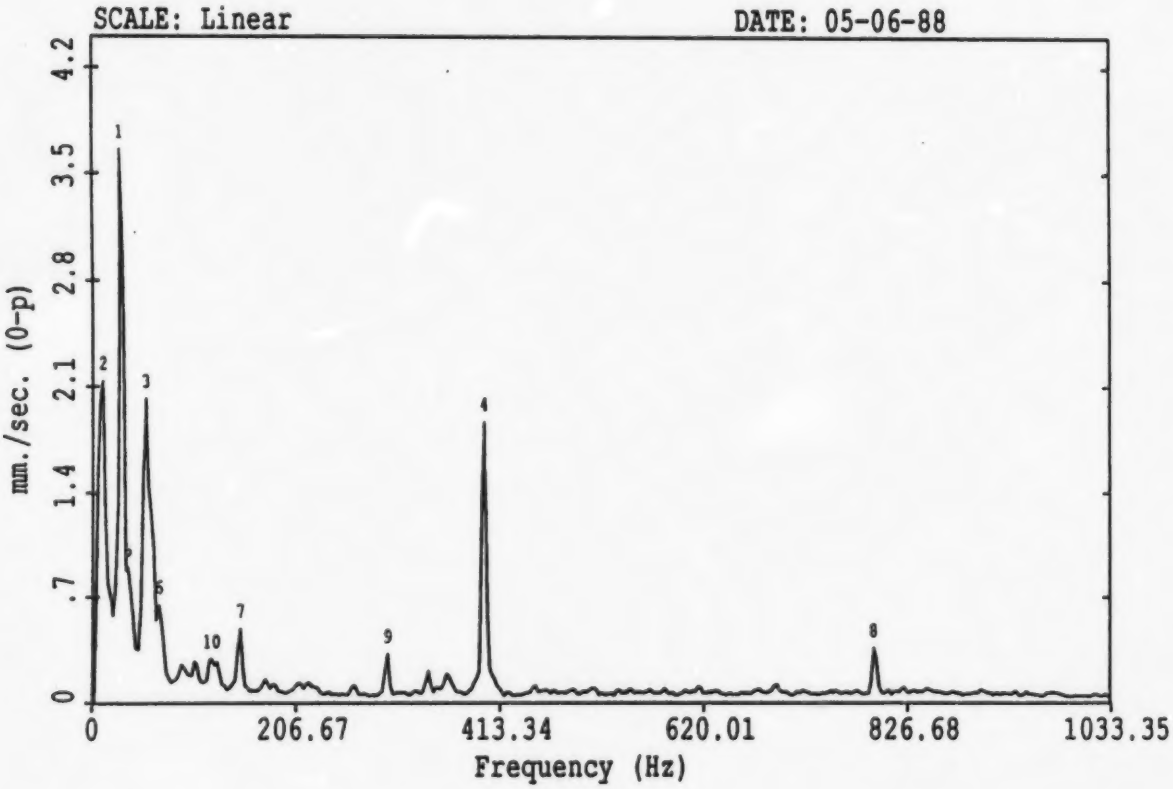


FIGURE 29

DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

SIGNAL : C12E Radial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	4.44
2	20.7	1.56
3	59.4	0.96
4	93.0	0.27
5	129.2	0.21
6	49.1	0.21
7	41.3	0.19
8	124.0	0.14
9	824.1	0.12
10	82.7	0.10

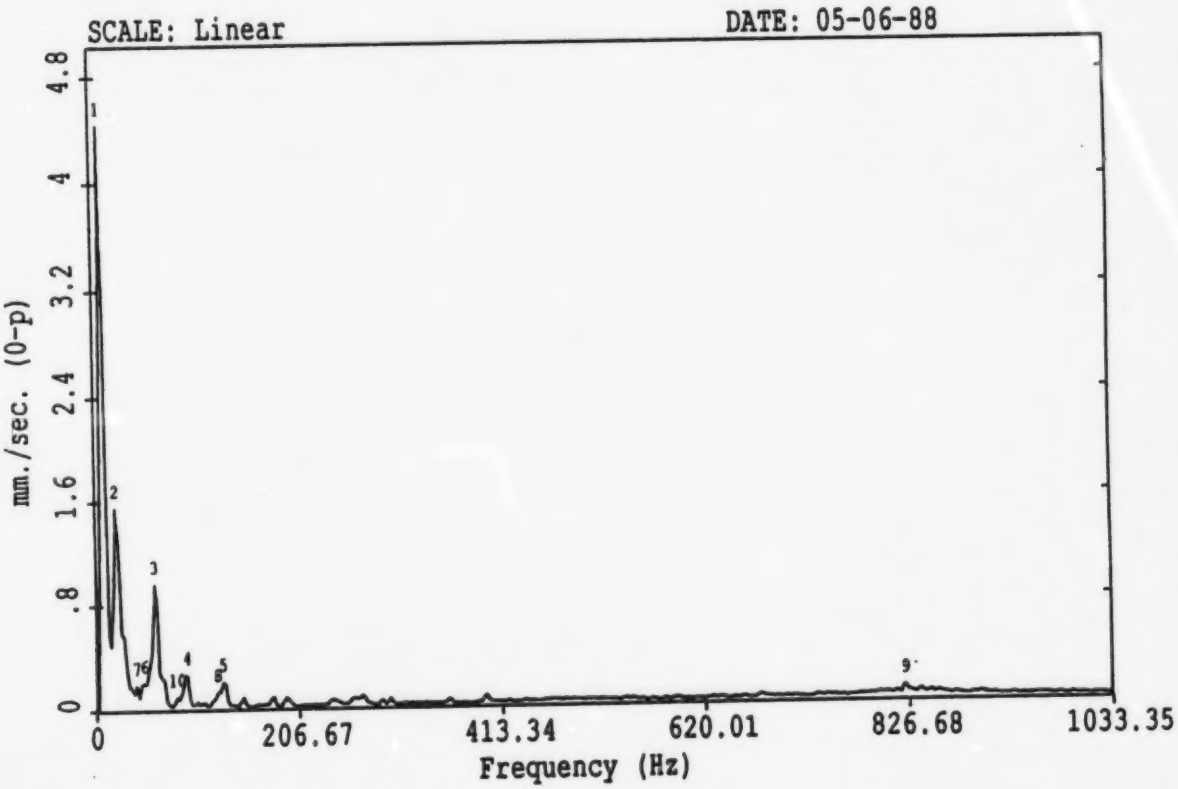


FIGURE 30

DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178344-RD

SIGNAL : ROH 7 Instr. Line radial velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	421.1	8.50
2	10.3	2.88
3	5.2	2.18
4	28.4	1.37
5	54.3	0.95
6	844.8	0.80
7	62.0	0.76
8	36.2	0.71
9	46.5	0.66
10	431.4	0.64

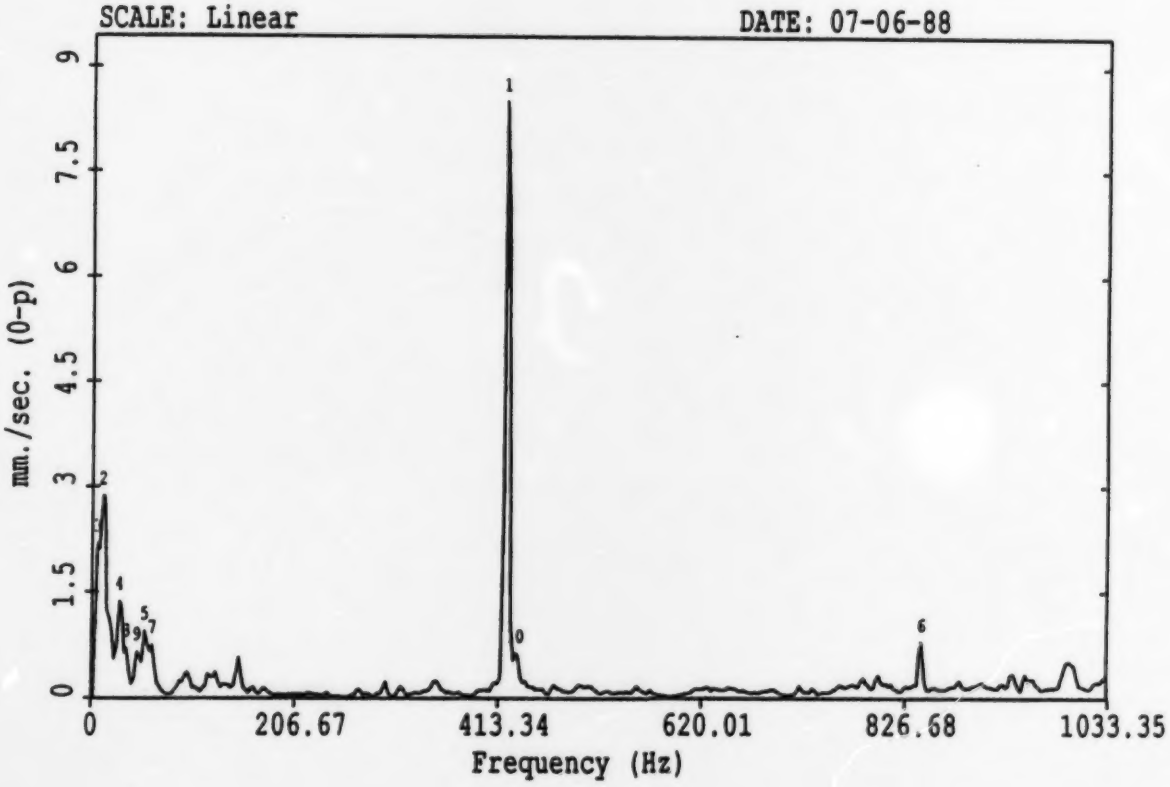


FIGURE 31

DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178345-RD

SIGNAL : C12E Transverse Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	421.1	8.56
2	10.3	1.45
3	59.4	0.72
4	28.4	0.46
5	98.2	0.34
6	46.5	0.23
7	392.7	0.21

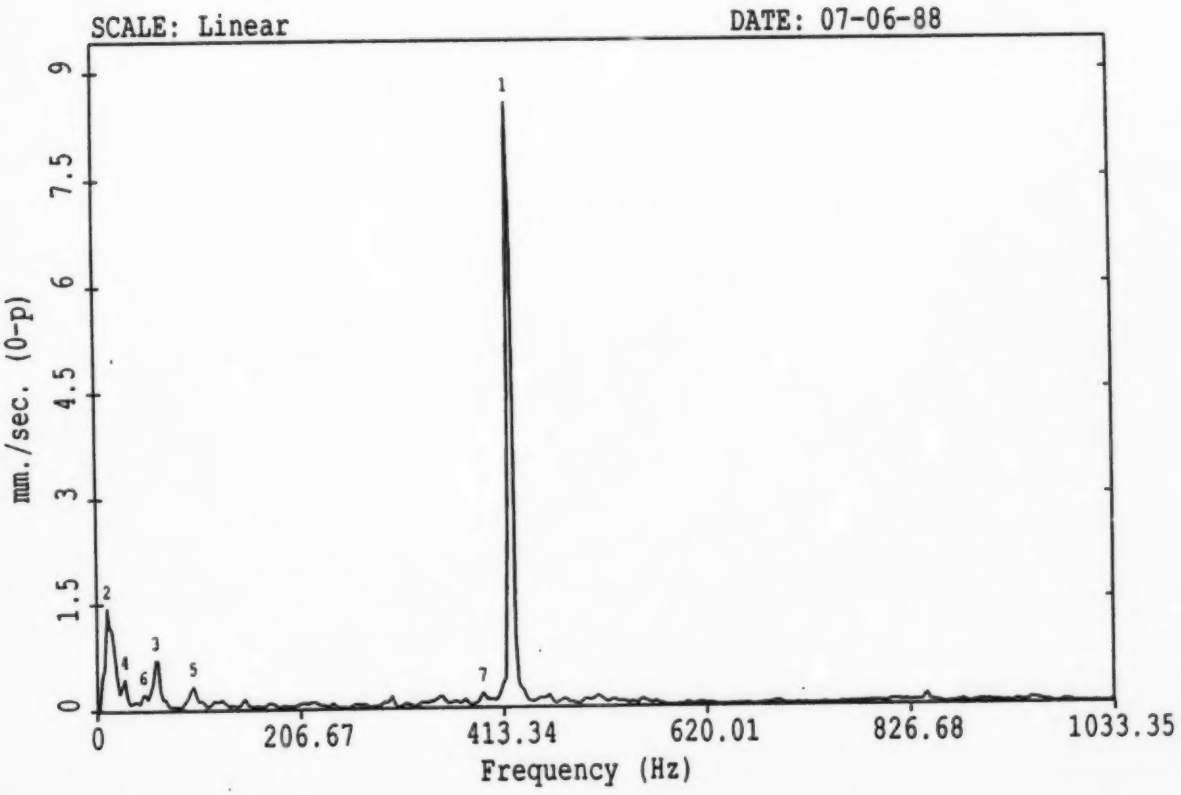


FIGURE 32
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

SIGNAL : C12E Axial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	421.1	8.56
2	10.3	1.45
3	59.4	0.72
4	28.4	0.46
5	98.2	0.34
6	46.5	0.23
7	392.7	0.21

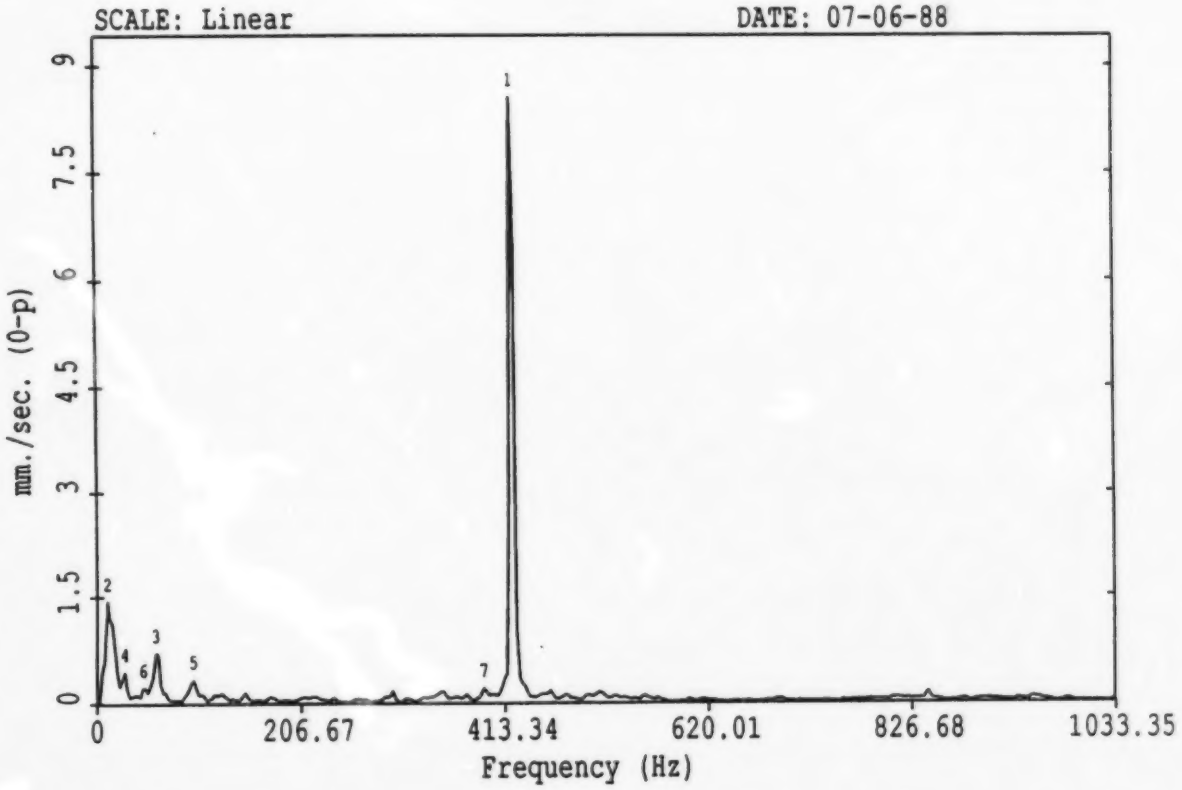


FIGURE 33
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

178347-RD

SIGNAL : C12E Radial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	31.0	4.61
2	421.1	4.51
3	56.8	2.67
4	10.3	2.63
5	20.7	0.83
6	121.4	0.67
7	149.8	0.60
8	90.4	0.34
9	105.9	0.30
10	95.6	0.29

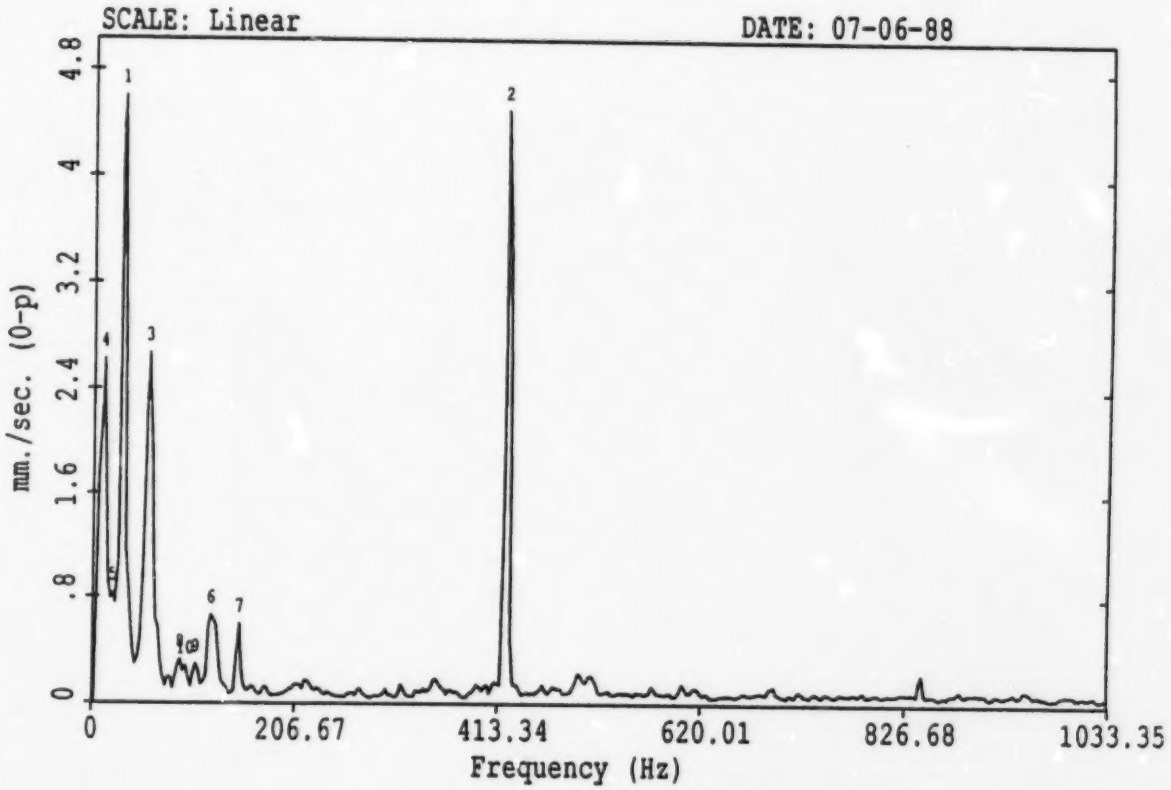


FIGURE 34
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION

SIGNAL : ROH 7 Instr. Line radial Velocity
PROCESS CONDITION : 90mm orifice Hot Tests - Pump 2 & 4 on, Pump 3 Turbining
T = 250°C

PEAK NO.	FREQUENCY	AMPLITUDE (mm/s peak)
1	7.8	7.40
2	28.4	1.16
3	62.0	0.86
4	23.3	0.81
5	90.4	0.24
6	69.8	0.19
7	421.1	0.18
8	38.8	0.17

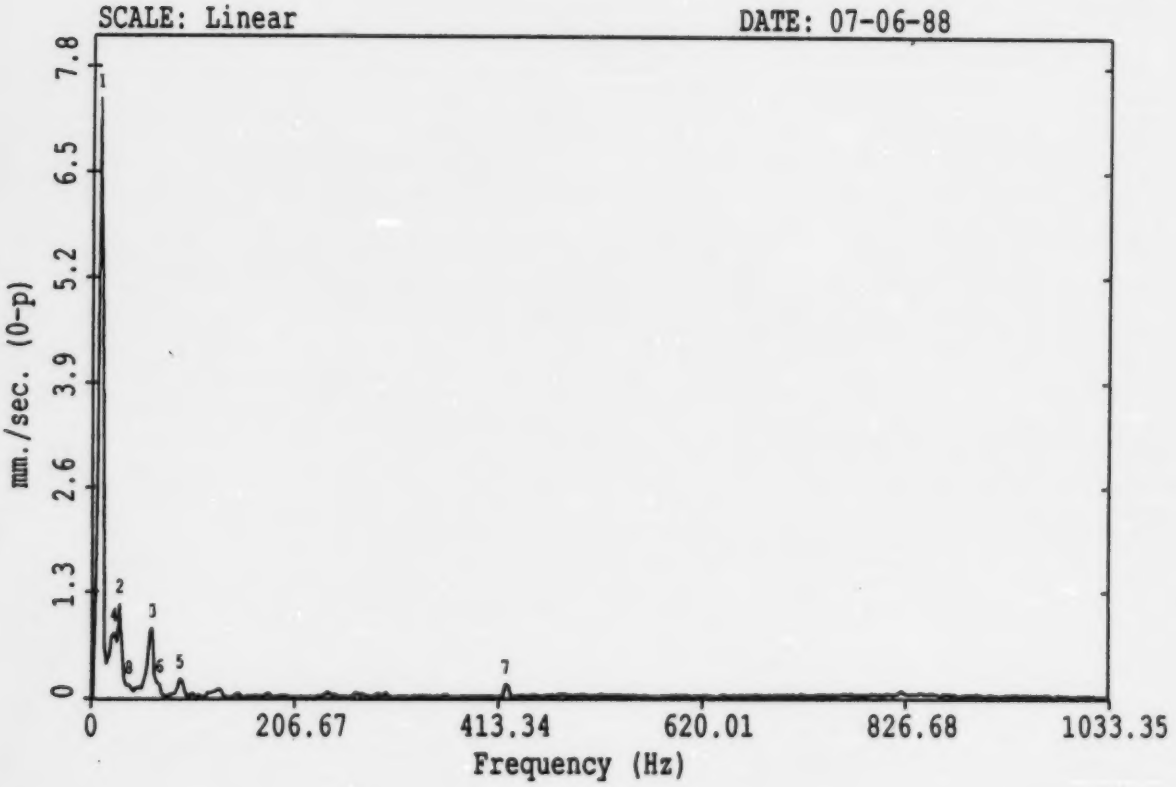


FIGURE 35
DARLINGTON NGS A UNIT 2 FEEDER VIBRATION